

The image is a presentation slide titled 'Introductions' for the 'FDOT HCS 2010' class. The slide has a light blue background with a faint collage of highway images and a hand reaching out. The title 'Introductions' is in a bold, dark blue font. Below the title is a bulleted list of names and questions. The FDOT logo and 'HCS 2010' are in the top left corner. A small number '2' is in the bottom right corner.

**FDOT HCS 2010**

## Introductions

- Tim White
- Brian Smalkoski
- Class participants
  - What module(s) in the HCS do you use most often?
  - What module(s) in the HCS do you rarely use?

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## Housekeeping

- Set phones to vibrate/silent
- Questions—ask lots of them at any time!
- Snacks available in the room
- Break
  - 2:30 – 2:45 pm

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## Day 1 – Interrupted Flow

- Overview
- Unsignalized Intersections
  - Two-Way Stop Control
  - All-Way Stop Control
- Roundabouts



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## Day 2 – Interrupted Flow

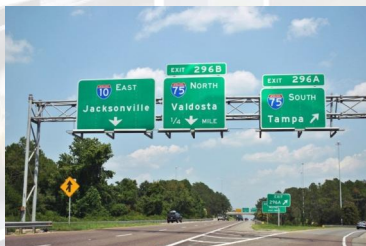
- Signalized Intersections
- Urban Streets
  - Segments
  - Facilities



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## Day 3 – Uninterrupted Flow (Mostly)

- Interchanges (interrupted flow)
- Freeways
  - Basic, weave, merge, and diverge segments
- Multi-lane highway segments
- Two-lane highway segments



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## Training Objectives

- To move beyond the basic concepts of traffic flow theory to hands-on capacity analysis, focusing on planning and operations
- To gain proficiency in capacity analysis through a range of exercises—from simple to complex
- To identify constraints of *HCS* through the analysis of over-capacity conditions
- To understand the factors that have the greatest impact on the results
- To identify some key changes between *HCM 2010* and *HCM 2000*

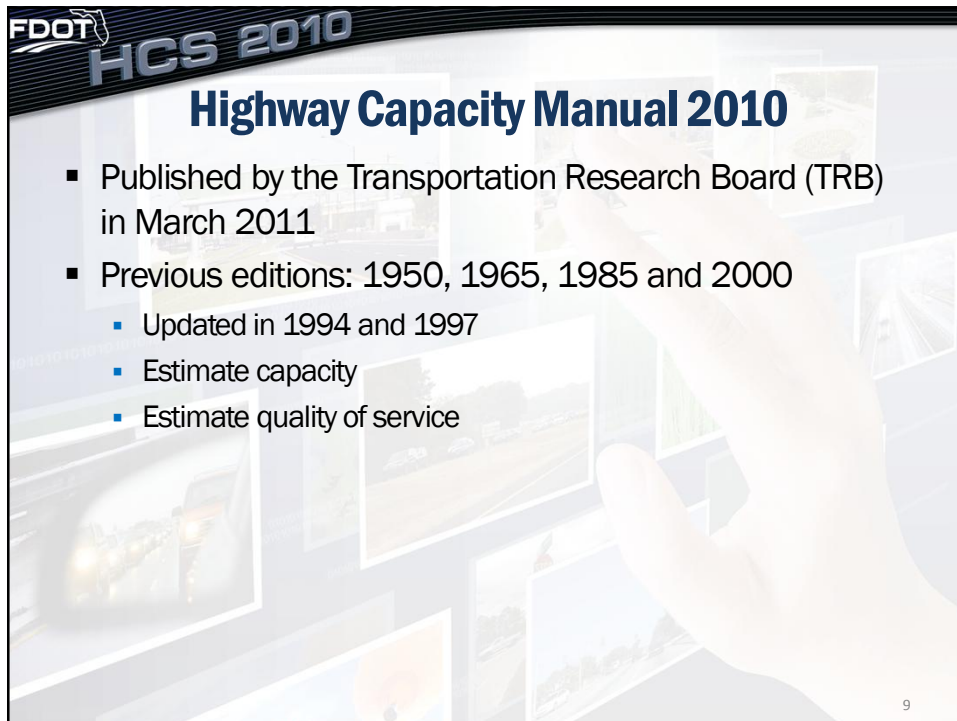
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## Format for Each Module

- Introduction to the module
- *HCM 2010* versus *HCM 2000*
- Required Data
- Limitations of the module
- Measures of Effectiveness (MOEs)
- Methodology
- Sample problem(s)
- Workshops

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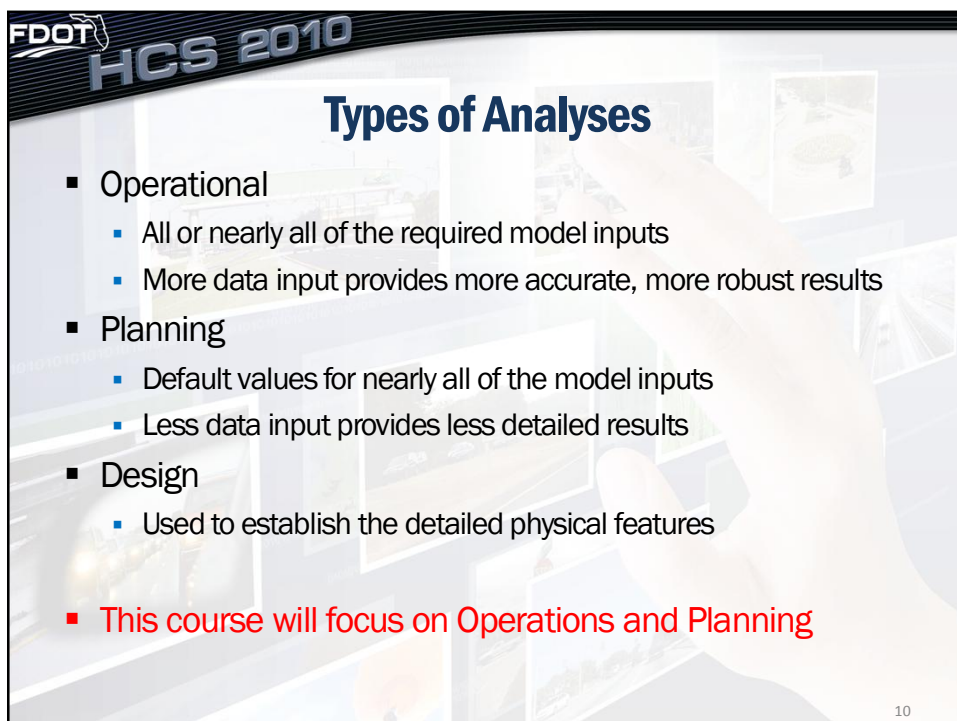


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## Highway Capacity Manual 2010

- Published by the Transportation Research Board (TRB) in March 2011
- Previous editions: 1950, 1965, 1985 and 2000
  - Updated in 1994 and 1997
  - Estimate capacity
  - Estimate quality of service

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## Types of Analyses

- Operational
  - All or nearly all of the required model inputs
  - More data input provides more accurate, more robust results
- Planning
  - Default values for nearly all of the model inputs
  - Less data input provides less detailed results
- Design
  - Used to establish the detailed physical features
- This course will focus on Operations and Planning

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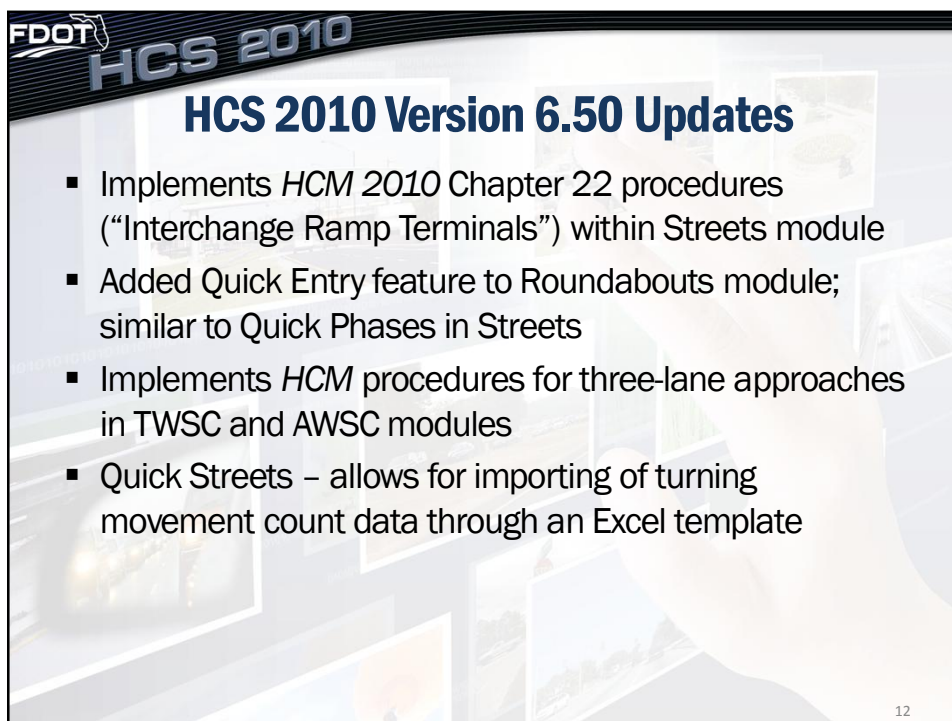




**Highway Capacity Software (HCS 2010)**

- Implements *HCM 2010* procedures & methodologies
- Follows *HCS2000*, *HCS+* and *HCS+T7F*
- Features *CORSIM* Quick Animation
- Major overhauls
  - New Roundabouts module
  - Updated Weaving module
  - New Visual Mode in Streets module
  - New Interchanges module

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**HCS 2010 Version 6.50 Updates**

- Implements *HCM 2010* Chapter 22 procedures (“Interchange Ramp Terminals”) within Streets module
- Added Quick Entry feature to Roundabouts module; similar to Quick Phases in Streets
- Implements *HCM* procedures for three-lane approaches in TWSC and AWSC modules
- Quick Streets – allows for importing of turning movement count data through an Excel template

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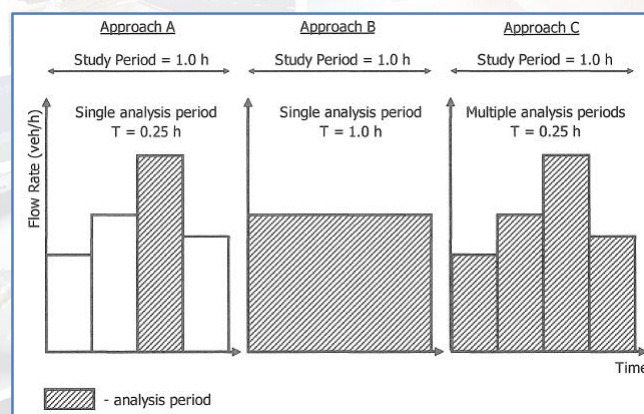
## Study Period vs Analysis Period

- Study period
  - Time interval represented by the performance evaluation
  - Consists of one or more consecutive analysis periods
- Analysis period
  - Time interval evaluated by a single application of the methodology
  - Range: 0.25 to 1.0 hours
  - Longer durations sometimes used for planning analyses
  - Avoid analysis periods that exceed 1.0 hr, because traffic conditions are not steady for long time periods
  - If evaluation of multiple analysis periods is important, then results from each period should be reported

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## Study Period vs Analysis Period

- Approach A is the recommended approach, which is based on the evaluation of the peak 15-minute period

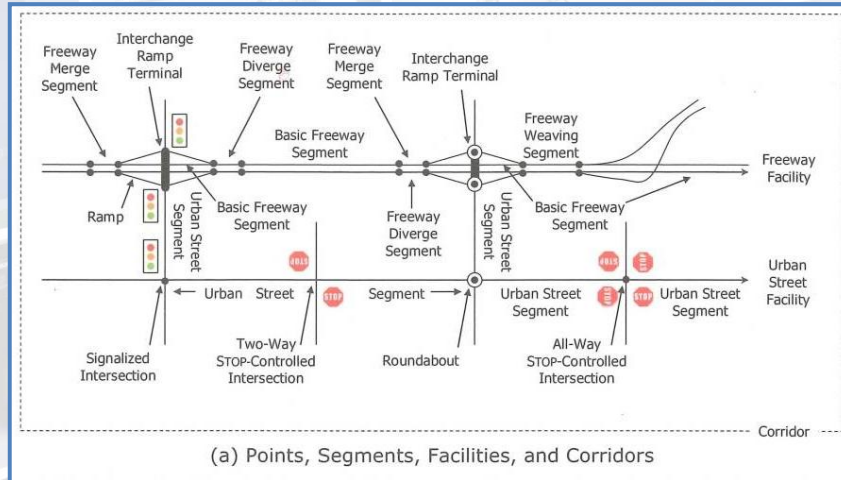


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## Types of Roadway System Elements

- HCM 2010 Exhibit 2-1a (Roadway System Elements)



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## Day 1 – Interrupted Flow

- Overview
- Unsignalized Intersections
  - Two-Way Stop Control ◀
  - All-Way Stop Control
- Roundabouts

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## Two-Way Stop Control (TWSC)

- Chapter 19 – HCM 2010
- Major Street/Minor Street
- Isolated intersections
- Level of Service criteria
  - Minor-street movements
  - Major-street left turns
- Applicable to automobiles, pedestrians & bicyclists
- New in 2010: gap acceptance parameters for 6-lane streets have been added

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## TWSC

- HCM 2010 Exhibit 19-1 (LOS for Automobiles)

Control Delay (s/vehicle)	LOS by Volume-to-Capacity Ratio	
	$v/c \leq 1.0$	$v/c > 1.0$
0-10	A	F
>10-15	B	F
>15-25	C	F
>25-35	D	F
>35-50	E	F
>50	F	F

Note: The LOS criteria apply to each lane on a given approach and to each approach on the minor street. LOS is not calculated for major-street approaches or for the intersection as a whole.

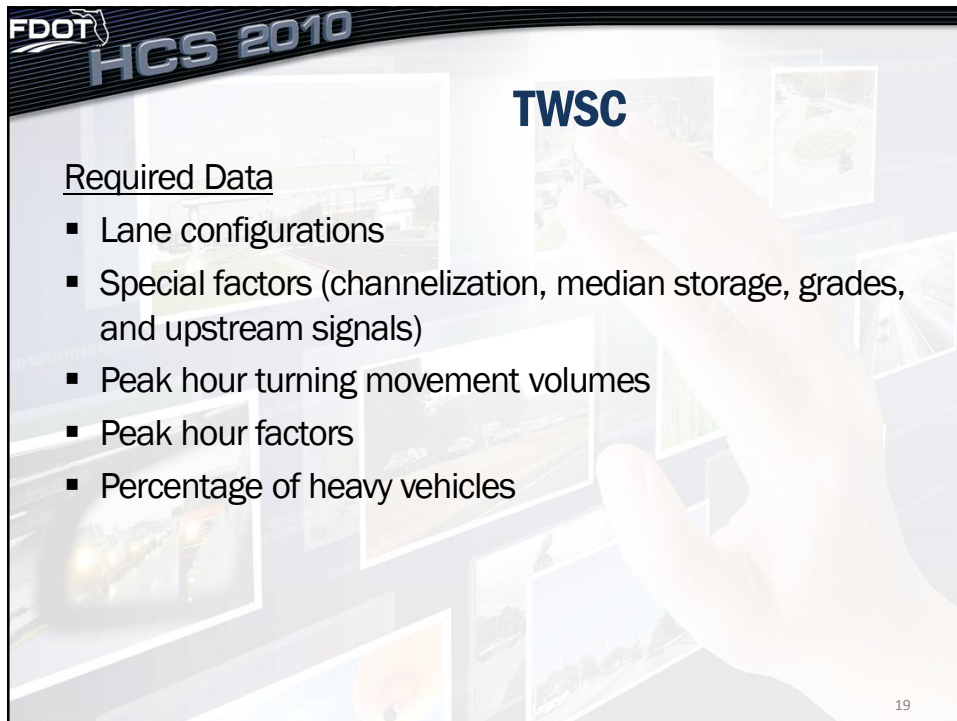
- HCM 2010 Exhibit 19-2 (LOS for Pedestrians)

LOS	Control Delay (s/pedestrian)	Comments
A	0-5	Usually no conflicting traffic
B	5-10	Occasionally some delay due to conflicting traffic
C	10-20	Delay noticeable to pedestrians, but not inconveniencing
D	20-30	Delay noticeable and irritating, increased likelihood of risk taking
E	30-45	Delay approaches tolerance level, risk-taking behavior likely
F	>45	Delay exceeds tolerance level, high likelihood of pedestrian risk taking

Note: Control delay may be interpreted as s/pedestrian group if groups of pedestrians were counted as opposed to individual pedestrians.

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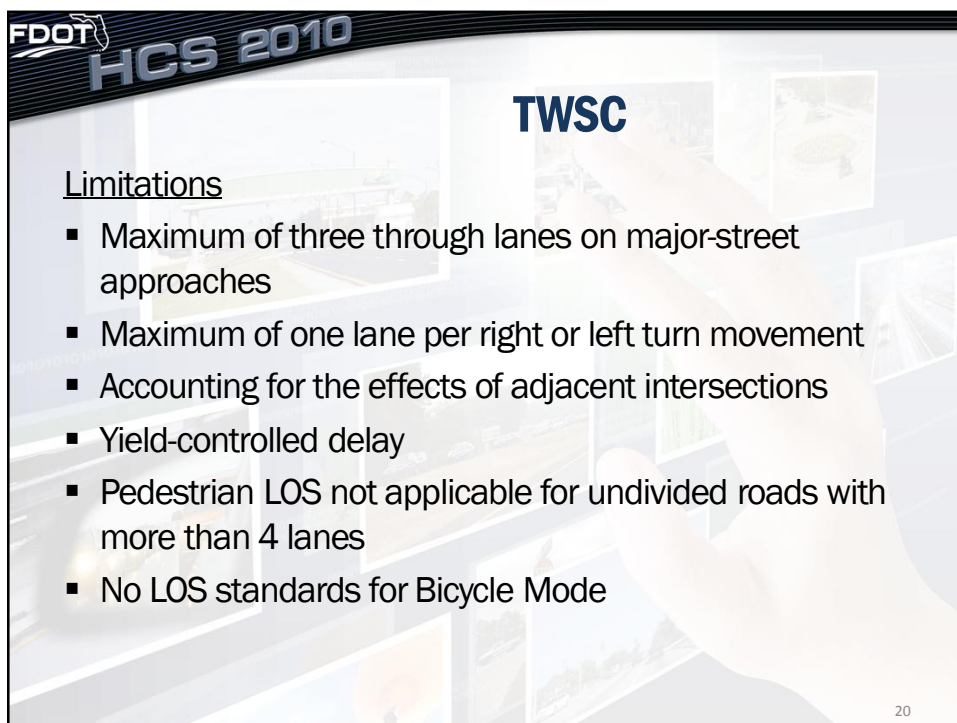
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## TWSC

Required Data

- Lane configurations
- Special factors (channelization, median storage, grades, and upstream signals)
- Peak hour turning movement volumes
- Peak hour factors
- Percentage of heavy vehicles

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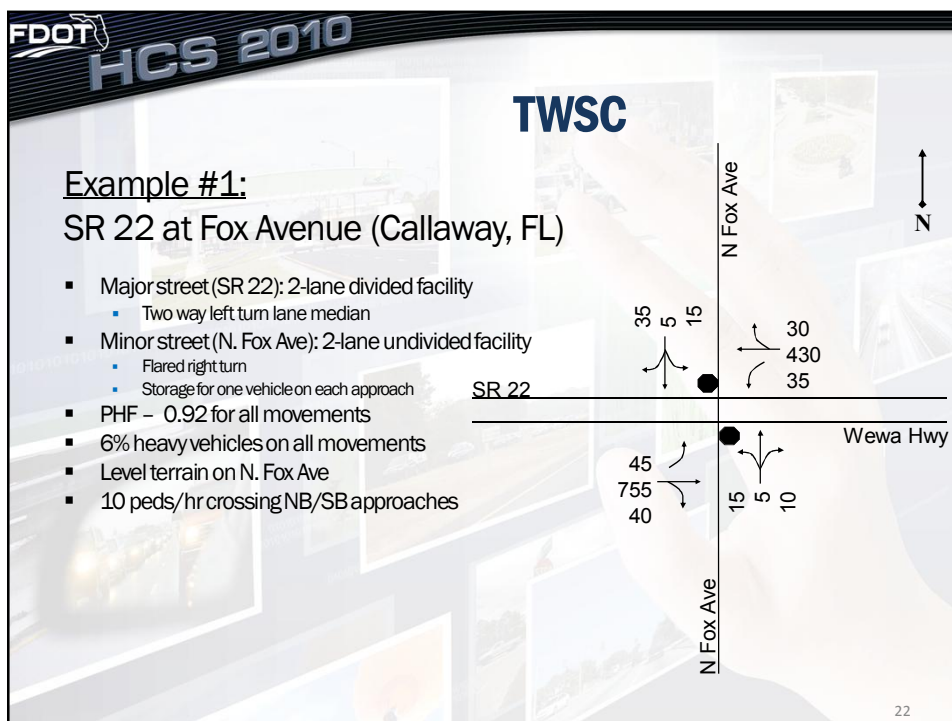
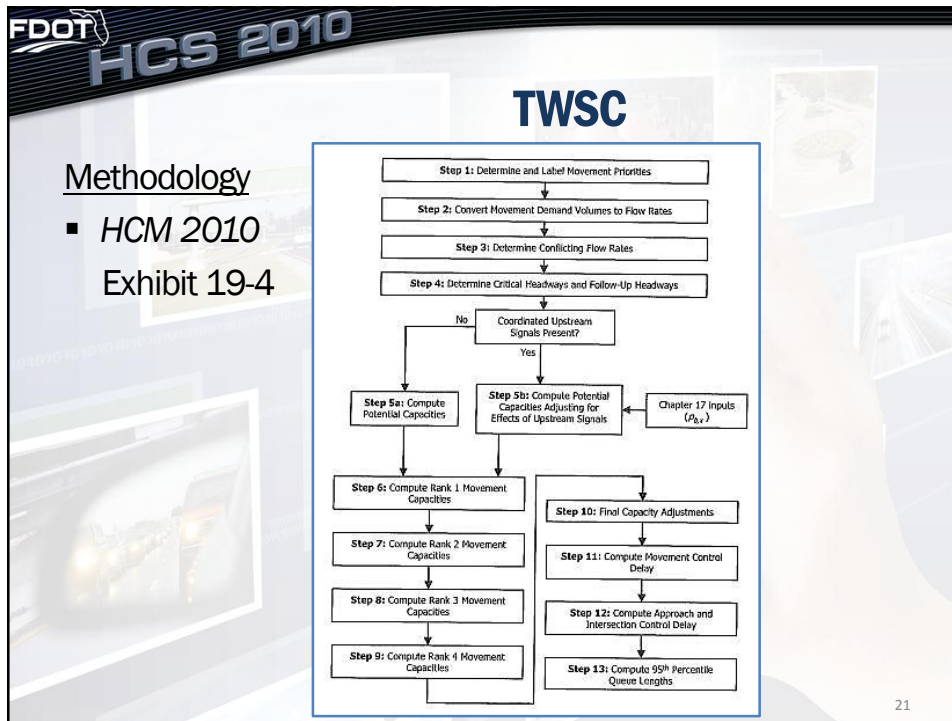
## TWSC

Limitations

- Maximum of three through lanes on major-street approaches
- Maximum of one lane per right or left turn movement
- Accounting for the effects of adjacent intersections
- Yield-controlled delay
- Pedestrian LOS not applicable for undivided roads with more than 4 lanes
- No LOS standards for Bicycle Mode

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## TWSC

Workshop #1:  
US-90 at Geddie Road (Tallahassee, FL)

- Major Street (US-90): 4-lane divided facility
  - Raised curb median
  - Storage in median for 1 vehicle
- Minor Street (Geddie Rd): 2-lane undivided facility
  - Channelized right turn
- PHF – 0.90 for all movements
- 9% heavy vehicles on all approaches
- Level terrain on Geddie Rd
- No pedestrian activity

US-90

Geddie Rd

550  
30

700  
80  
30  
80

US-90

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## TWSC

**Workshop #2:**  
SR 924 at 22<sup>nd</sup> Court (Miami, FL)

- Major street (SR 924): 4-lane divided facility
  - Raised curb median
  - Storage in median for 1 vehicle
- Minor street (NW 22<sup>nd</sup> Ct): 2-lane undivided facility
- 0.89 – PHF for all approaches
- 3% heavy vehicles on all movements
- Level terrain on NW 22<sup>nd</sup> Ct
- No pedestrian activity
- Upstream traffic signal (420' to the west)
  - 35 MPH progression speed
  - 120 second cycle length
  - Progressed volume – 850 vehicles/hr
  - Arrival type 5
  - Effective green – 45 seconds

SR 924

Gratigny Pkwy

NW 22<sup>nd</sup> Ct

1380  
45

970  
5

15  
35

N

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## TWSC

**Workshop #3:**  
Pine Crest Avenue at M.L. King Jr. Boulevard

- Pine Crest Ave (western leg): 4-lane divided facility
  - Free-flow channelized right-turn lane with receiving lane
  - Raised curb median with no storage
- Pine Crest Ave (eastern leg): 2-lane undivided facility
- Minor Street (ML King Jr. Blvd): 4-lane undivided facility
- PHF – 0.90 for all approaches
- No grades
- 2% heavy vehicles on all movements
- No pedestrian activity

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## Day 1 – Interrupted Flow

- Overview
- Unsignalized Intersections
  - Two-Way Stop Control
  - All-Way Stop Control ◀
- Roundabouts

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## All-Way Stop Control (AWSC)

- Chapter 20 – HCM 2010
- Every vehicle required to stop
- Isolated intersections
- New in 2010: a queue estimation model has been added

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## AWSC

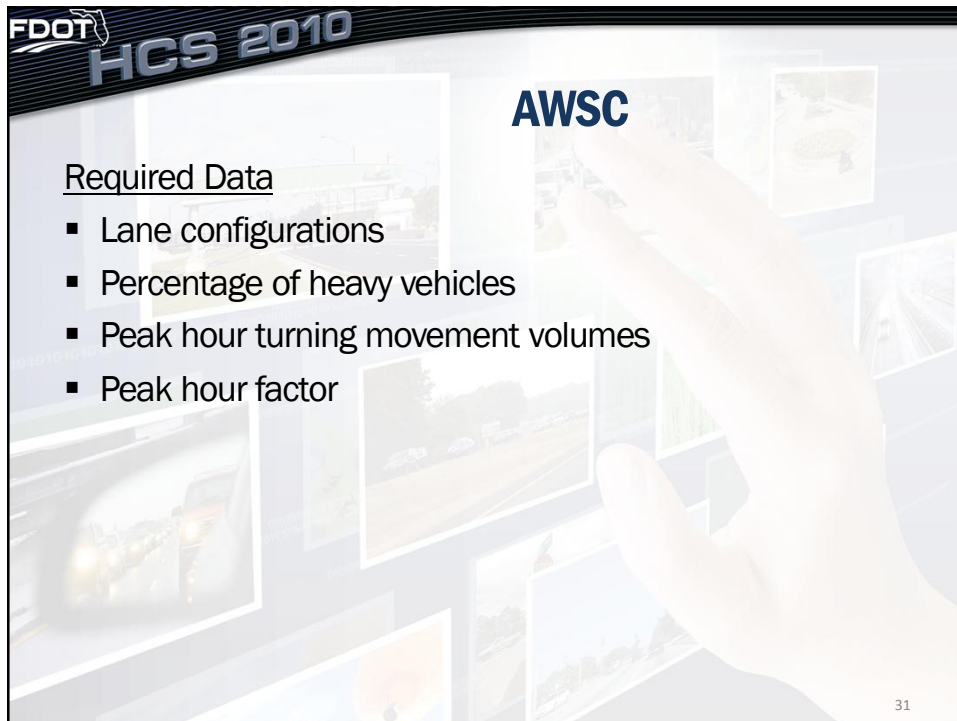
- HCM 2010 Exhibit 20-2 (LOS for Automobiles)

Control Delay (s/veh)	LOS by Volume-to-Capacity Ratio*	
	$v/c \leq 1.0$	$v/c > 1.0$
0-10	A	F
>10-15	B	F
>15-25	C	F
>25-35	D	F
>35-50	E	F
>50	F	F

Note: \* For approaches and intersectionwide assessment, LOS is defined solely by control delay.

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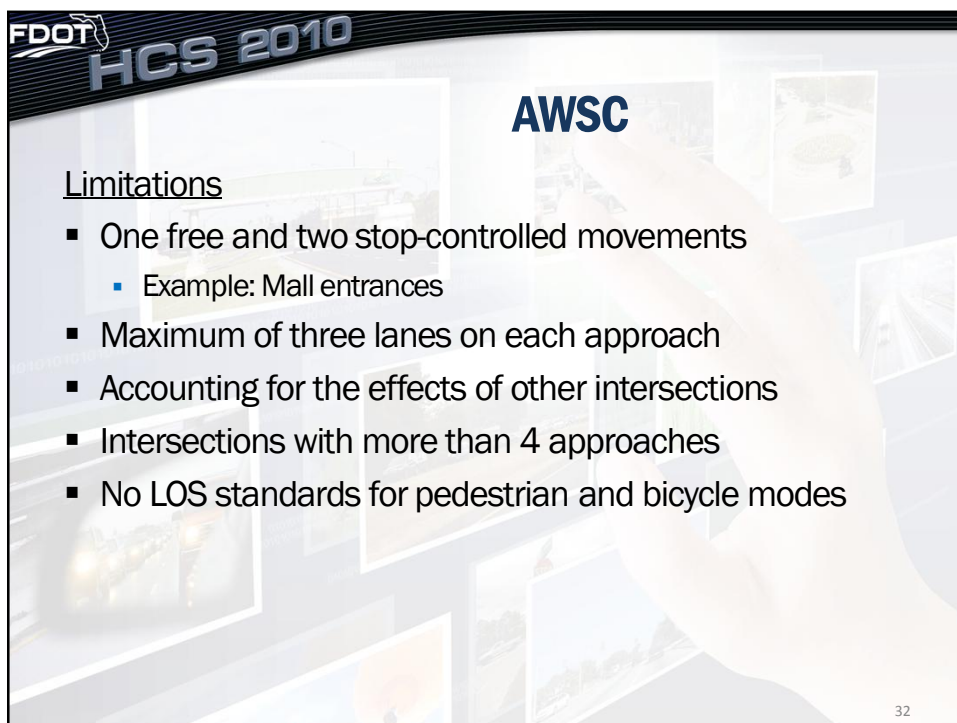
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## AWSC

Required Data

- Lane configurations
- Percentage of heavy vehicles
- Peak hour turning movement volumes
- Peak hour factor

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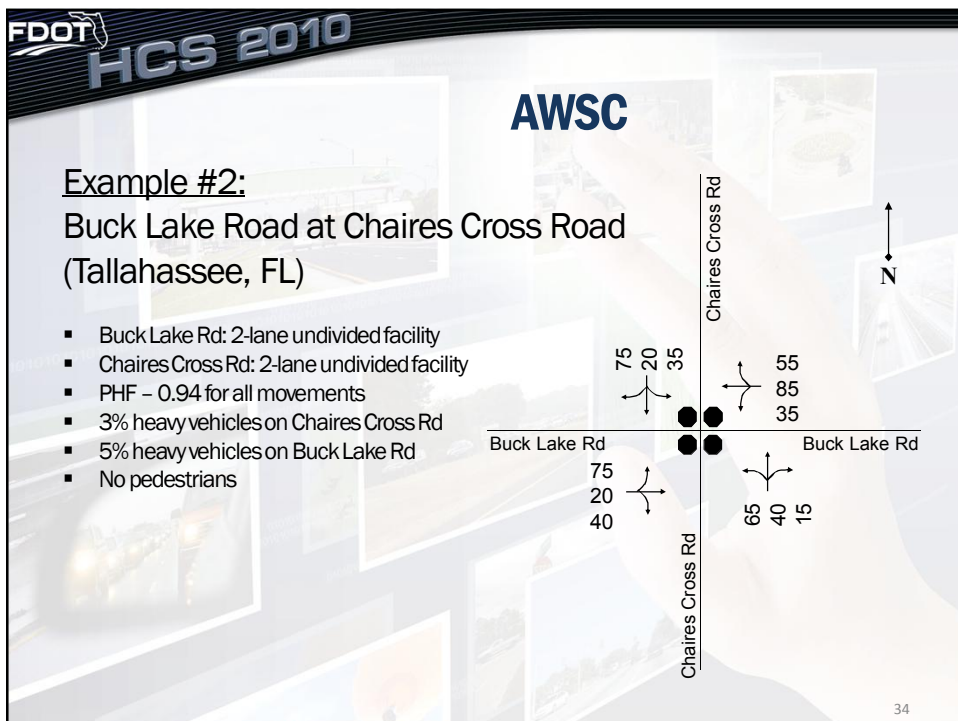
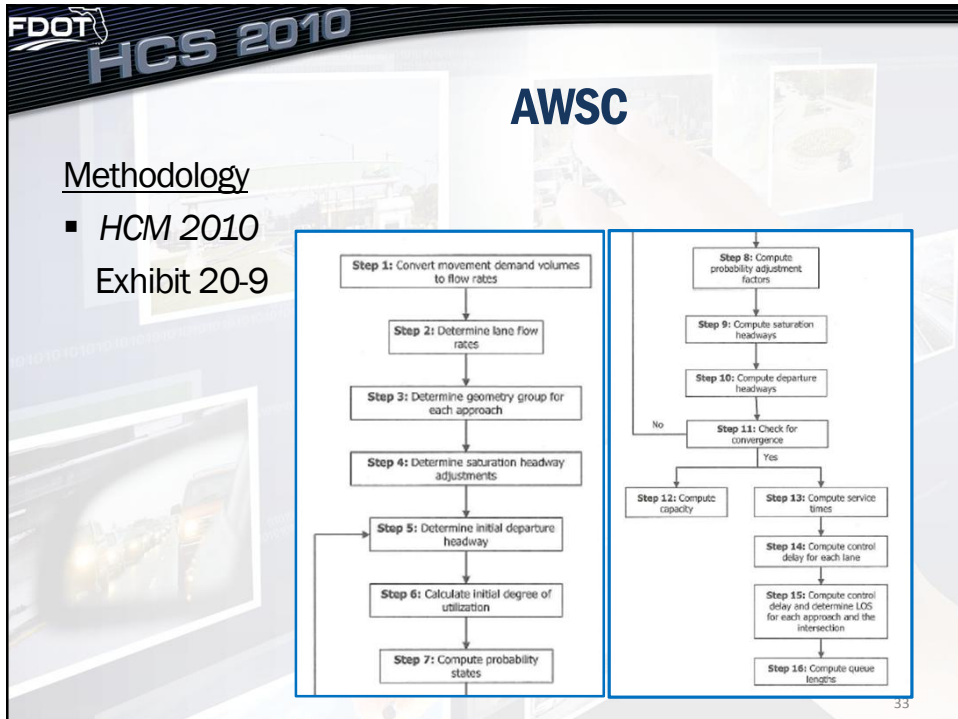
## AWSC

Limitations

- One free and two stop-controlled movements
  - Example: Mall entrances
- Maximum of three lanes on each approach
- Accounting for the effects of other intersections
- Intersections with more than 4 approaches
- No LOS standards for pedestrian and bicycle modes

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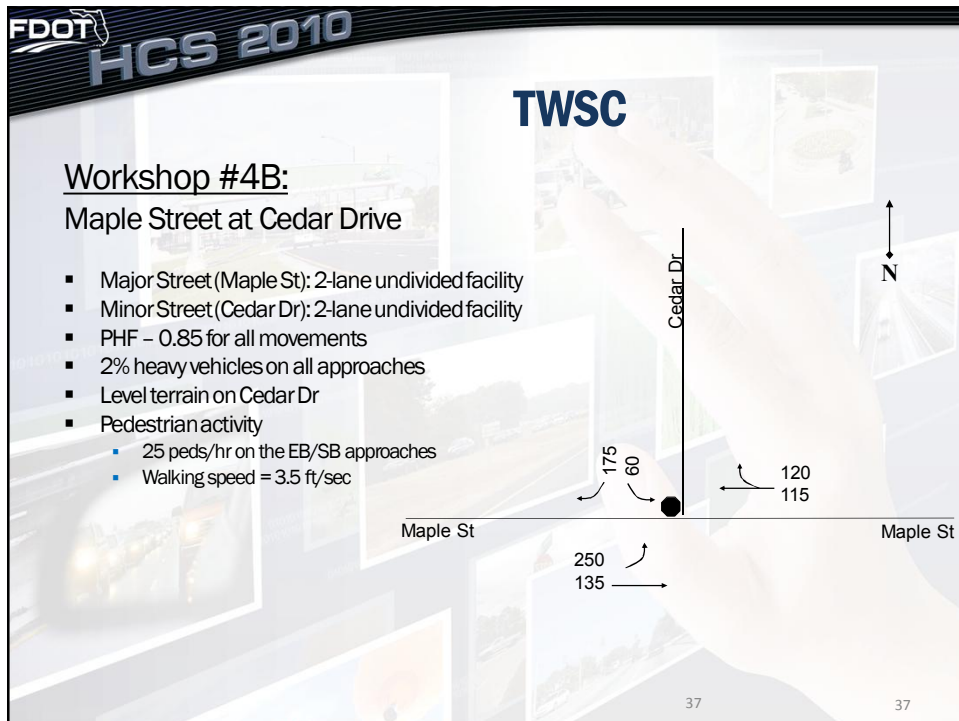














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## Day 1 – Interrupted Flow

- Overview
- Unsignalized Intersections
  - Two-Way Stop Control
  - All-Way Stop Control
- Roundabouts ◀

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## Roundabouts

- Chapter 21 – *HCM 2010*
- Single-lane or multi-lane roundabouts
- Automobiles only
  - Pedestrian activity accounted for, but not given LOS
- Level of Service criteria based on *HCM 2010*
  - Control delay
  - Volume/capacity ratio
- New roundabout analysis methodology in *HCM 2010* based on NCHRP 3-65

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## Roundabouts

- HCM 2010 Exhibit 21-9

```

graph TD
    Step1[Step 1: Convert movement demand volumes to flow rates] --> Step2[Step 2: Adjust flow rates for heavy vehicles]
    Step2 --> Step3[Step 3: Determine circulating and exiting flow rates]
    Step3 --> Step4[Step 4: Determine entry flow rates by lane]
    Step4 --> Step5[Step 5: Determine the capacity of each entry lane and bypass lane as appropriate in passenger car equivalents]
    Step5 --> Step6[Step 6: Determine pedestrian impedance to vehicles]
    Step6 --> Step7[Step 7: Convert lane flow rates and capacities into vehicles per hour]
    Step7 --> Step8[Step 8: Compute the volume-to-capacity ratio for each lane]
    Step8 --> Step9[Step 9: Compute the average control delay for each lane]
    Step9 --> Step10[Step 10: Determine LOS for each lane on each approach]
    Step10 --> Step11[Step 11: Compute the average control delay and determine LOS for each approach and the roundabout as a whole]
    Step11 --> Step12[Step 12: Compute 95th percentile queues for each lane]
  
```

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## Roundabouts

### Required Data

- Traffic characteristics
  - Percentage of heavy vehicles
  - Peak hour turning movement volumes
    - Includes u-turn volumes
- Geometric configuration
  - Lane configurations
  - Right-turn bypass lanes

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## Roundabouts

### Limitations

- The effects of upstream intersections
  - Upstream/downstream signalized intersections
  - Nearby roundabouts
- More than two entry lanes on an approach (HCM)
- High level of pedestrian/bicycle activity
- Methodology to determine pedestrian/bicycle LOS

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## Roundabouts

### Example #3:

Morse Boulevard at Odell Circle  
(The Villages, FL)

- Morse Boulevard
  - 4-lane divided facility
- Odell Circle
  - 2-lane undivided facility
- 2 circulating lanes
- No right-turn bypass lane
- No pedestrians
- PHF – 0.96 for all approaches
- 3% heavy vehicles on all approaches

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## Roundabouts



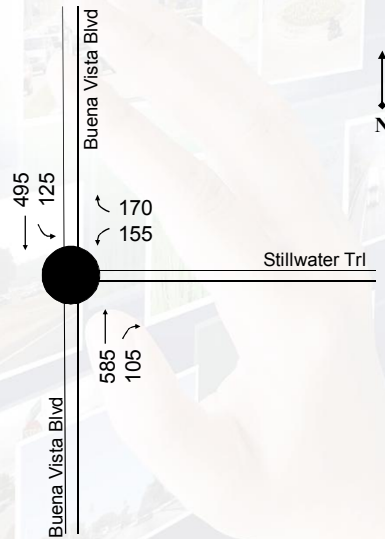
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## Roundabouts

### Workshop #6:

Buena Vista Blvd at Stillwater Trail  
(The Villages, FL)

- Buena Vista Blvd
  - 4-lane divided facility with 16' median
- Stillwater Trl
  - 4-lane divided facility with 16' median
- 2 circulating lanes
- No right-turn bypass lanes
- No pedestrians
- PHF – 0.92 for all approaches
- 2% heavy vehicles on all movements



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## Roundabouts



An aerial photograph of a roundabout intersection. Four red 'X' marks are placed on the approach roads: one on the north approach, one on the west approach, one on the south approach, and one on the east approach. The roundabout is a single-lane roundabout with a central island. Surrounding streets include Burnside Blvd, Shilwater Rd, and Shilwater Trl. The background shows a residential area with houses and trees.

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## Day 2 – Interrupted Flow

- Signalized Intersections ◀
- Urban Streets
  - Segments
  - Facilities



Aerial view of a signalized intersection. The image shows a multi-lane intersection with traffic lights. The background shows a residential area with houses and trees.

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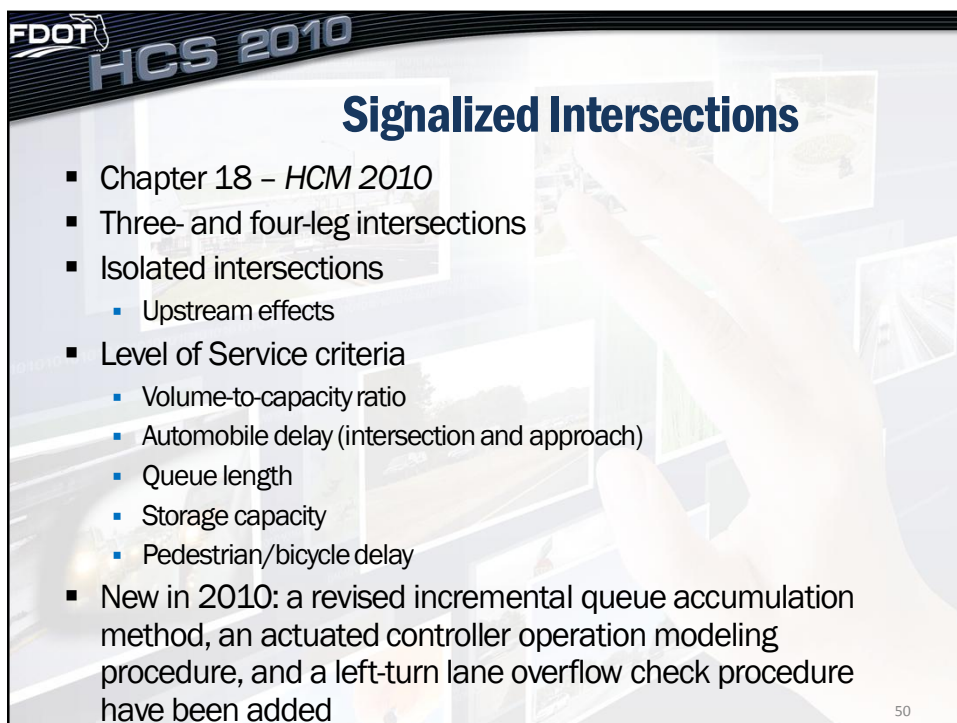


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## Housekeeping

- Breaks
  - 10:00 – 10:15 am
  - Lunch 11:30 – 1:00 pm
  - 2:30 – 2:45 pm

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## Signalized Intersections

- Chapter 18 – *HCM 2010*
- Three- and four-leg intersections
- Isolated intersections
  - Upstream effects
- Level of Service criteria
  - Volume-to-capacity ratio
  - Automobile delay (intersection and approach)
  - Queue length
  - Storage capacity
  - Pedestrian/bicycle delay
- New in 2010: a revised incremental queue accumulation method, an actuated controller operation modeling procedure, and a left-turn lane overflow check procedure have been added

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## Signalized Intersections

- HCM 2010 Exhibit 18-4 (LOS for Automobiles)

Control Delay (s/veh)	LOS by Volume-to-Capacity Ratio <sup>a</sup>	
	≤1.0	>1.0
≤10	A	F
>10–20	B	F
>20–35	C	F
>35–55	D	F
>55–80	E	F
>80	F	F

Note: <sup>a</sup> For approach-based and intersectionwide assessments, LOS is defined solely by control delay.

- HCM 2010 Exhibit 18-5 (LOS for Peds/Bicycles)

LOS	LOS Score
A	≤2.00
B	>2.00–2.75
C	>2.75–3.50
D	>3.50–4.25
E	>4.25–5.00
F	>5.00

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## Signalized Intersections

### Required Data

- Lane configurations
- Percentage of heavy vehicles
- Peak hour turning movement volumes
- Peak hour factor or 15-minute traffic volumes
- Traffic signal phasing
- Traffic signal timing parameters

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## Signalized Intersections

### Limitations

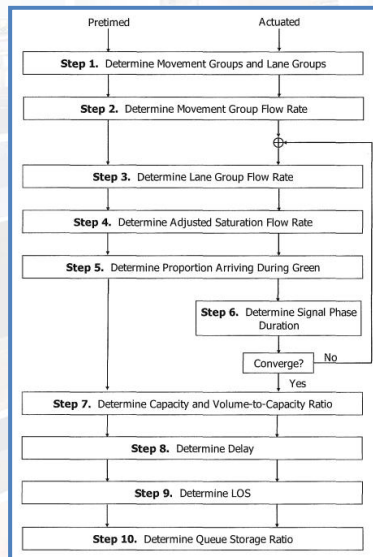
- Calibration
- Turn bay overflow
- Demand starvation
- Right turn on red (RTOR) volume
- Effects to/from upstream intersections
- Effects of add/drop lanes near intersection
- Controller functions (overlap, gap reduction)
- Pedestrian/bicycle (grades >2%, railroad crossing)

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## Signalized Intersections

### Methodology

- HCM 2010  
Exhibit 18-11



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## Signalized Intersections

### Actuation

- Vehicle detection for an approach

Diagram illustrating a signalized intersection with Main Street and Side Street. The intersection is labeled "Self-Actuated". Detectors (yellow squares) are shown on both streets, connected to a traffic signal (red, yellow, green circles). The diagram shows the layout of the intersection and the placement of detectors for vehicle detection.

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## Signalized Intersections

### Terminology

- Cycle length:** The amount of time (in seconds) that is provided to service all movements at a signalized intersection; a cycle length should provide sufficient capacity at the critical intersection(s) and provide progression through the system

Diagram illustrating the cycle length of a signalized intersection. The cycle is divided into two phases: 50 seconds and 40 seconds, totaling 90 seconds. The 50-second phase includes left-turn (15s), through (35s), and right-turn (15s) movements. The 40-second phase includes left-turn (20s), through (30s), and right-turn (10s) movements. The total cycle length is 90 seconds.

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## Signalized Intersections

### Terminology

- **Minimum green time:** Minimum amount of green time (in seconds) that a vehicle movement receives. Typically a set standard adopted by each agency.
  - Typically range from 4 to 15 seconds
- **Maximum green time:** Maximum amount of green time (in seconds) that a green signal indication can be displayed in the presence of conflicting demand.
  - Typical ranges:
    - 15 to 30 seconds (left turn phases)
    - 20 to 40 seconds (through phase for minor street approach)
    - 30 to 60 seconds (through phase for major street approach)

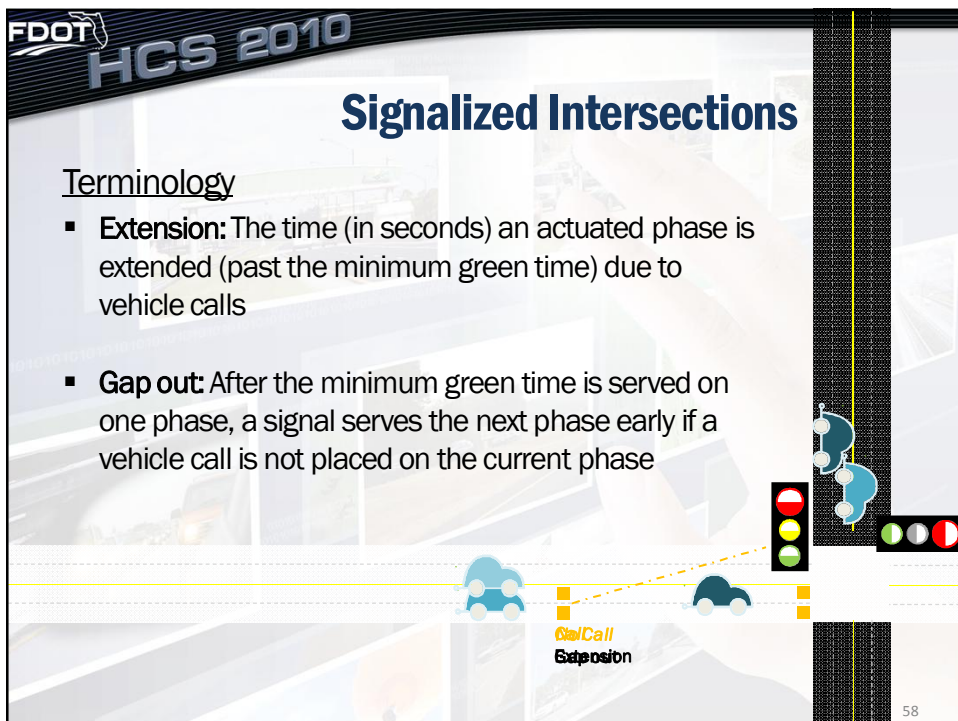
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## Signalized Intersections

### Terminology

- **Extension:** The time (in seconds) an actuated phase is extended (past the minimum green time) due to vehicle calls
- **Gap out:** After the minimum green time is served on one phase, a signal serves the next phase early if a vehicle call is not placed on the current phase



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## Signalized Intersections

### Terminology

- **Vehicle clearance time:** Yellow time + all-red time
  - Yellow time is based on the approach speed & grade
  - All-red time is based on the approach speed & intersection width
- **Platoon:** Group of vehicles traveling together through a coordinated system



The diagram shows a green arrow pointing left with '20 s' next to it, followed by a yellow bar and a red bar. Below these is a label 'Vehicle Clearance Time'. Below the main text, three blue car icons are shown in a line, with the label 'Platoon' underneath them.

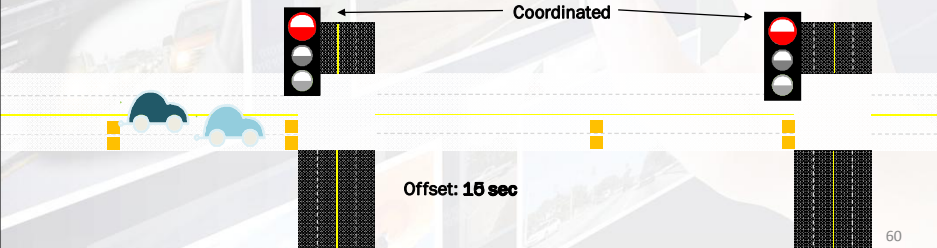
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## Signalized Intersections

### Terminology

- **Coordinated system:** A system of interconnected traffic signals that are timed to maximize flow along a major street
- **Offset:** The time delay (in seconds) between the start of a cycle at a “master” intersection in a coordinated system and another intersection—typically set so that the light turns green when you arrive at the next traffic signal



The diagram shows two traffic light icons connected by a double-headed arrow labeled 'Coordinated'. Below the lights, a road is shown with two cars. A label 'Offset: 15 sec' is placed between the two intersections.

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## Signalized Intersections

### Terminology

- **Recall:** Whether or not the controller will automatically place a call for a specified phase each time the controller is servicing a conflicting phase
  - **Off:** A phase will not automatically place a call; also called None
  - **Minimum recall:** A phase will automatically place a call and only allocate the minimum green time to the phase unless subsequent calls are placed
  - **Maximum recall:** A phase will place a call each time and the maximum green time or split will be allocated to the phase. All phases should be considered as maximum recall for pre-timed traffic signals
  - **Pedestrian recall:** The controller will place a continuous call for pedestrian service on the phase and then service the phase for at least an amount of time equal to its walk and pedestrian clear intervals (more if vehicle detections are received). Pedestrian recall is used for phases that have a high probability of pedestrian demand every cycle and no pedestrian detection.

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## Signalized Intersections

### Terminology

- **Pedestrian timings:** Whether or not the controller will automatically place a call for a specified phase each time the controller is servicing a conflicting phase
  - **Walk interval:** The walk interval is intended to give pedestrians adequate time to perceive the WALK indication and depart the curb before the pedestrian change interval begins
  - **Pedestrian clearance:** A flashing DON'T WALK or countdown timer indication is displayed during this interval



Walk Interval: ■ sec

Pedestrian Clearance: ■ sec

DON'T  
WALK

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# Signalized Intersections

## National Electrical Manufacturers Association (NEMA) Phasing

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# Signalized Intersections

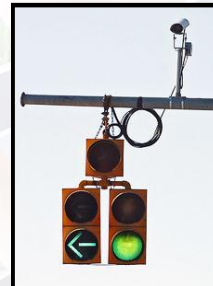
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## Signalized Intersections

### Left-Turn Phasing

- **Protected turn:** A green arrow
- **Permissive turn:** A green ball (or flashing yellow arrow) where left turns have to yield to oncoming traffic
- **Protected + Permissive turn:** Starts as green arrow, changes to green ball (or vice versa)

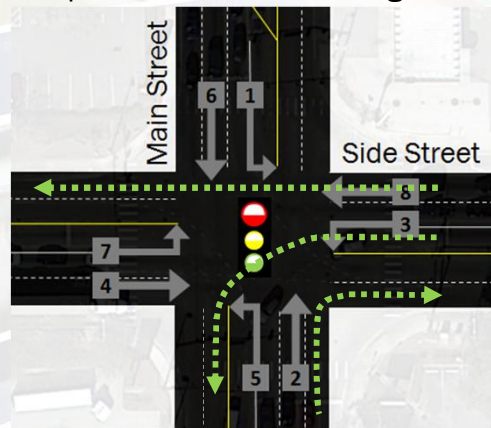


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## Signalized Intersections

### Overlap Phasing

- Right-turn movements operating in exclusive lanes assigned to more than one phase that is not conflicting



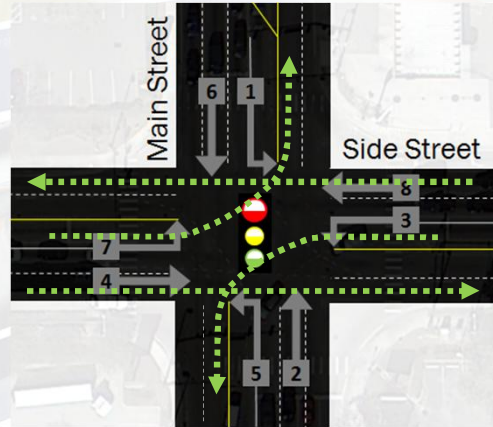
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## Signalized Intersections

### Split Phasing

- Having two opposing approaches time consecutively rather than concurrently

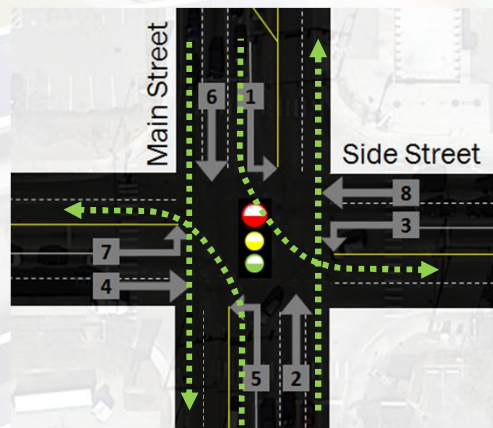


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## Signalized Intersections

Lead: Phasing in which left turn phase precedes opposing through phase

Lag: Phasing in which left turn phase follows opposing through phase



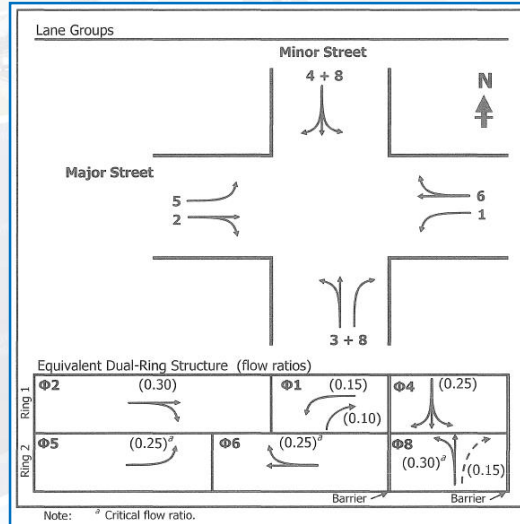
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## Signalized Intersections

### Critical Paths

- HCM 2010  
Exhibit 18-15



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## Signalized Intersections

### Arrival Type

- Describes the quality of signal progression
- Values range from 1 to 6
  - Value of 1 represents poor progression
  - Value of 3 represents random arrivals
  - Value of 6 represents exceptional progression
- Typically, arrival type 3 used for uncoordinated movements and arrival type 4 used for most coordinated movements

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## Signalized Intersections


- HCM 2010 Exhibit 18-8

Platoon Ratio	Arrival Type	Progression Quality
0.33	1	Very poor
0.67	2	Unfavorable
1.00	3	Random arrivals
1.33	4	Favorable
1.67	5	Highly favorable
2.00	6	Exceptionally favorable

- HCM 2010 Exhibit 18-29

Arrival Type	Progression Quality	Signal Spacing (ft)	Conditions Under Which Arrival Type Is Likely to Occur
1	Very poor	≤1,600	Coordinated operation on a two-way street where the subject direction does not receive good progression
2	Unfavorable	>1,600–3,200	A less extreme version of Arrival Type 1
3	Random arrivals	>3,200	Isolated signals or widely spaced coordinated signals
4	Favorable	>1,600–3,200	Coordinated operation on a two-way street where the subject direction receives good progression
5	Highly favorable	≤1,600	Coordinated operation on a two-way street where the subject direction receives good progression
6	Exceptional	≤800	Coordinated operation on a one-way street in dense networks and central business districts

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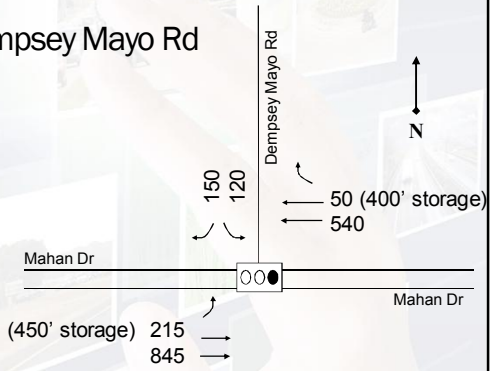


## Signalized Intersections

**Example #4: Mahan Dr at Dempsey Mayo Rd (Tallahassee, FL)**

- Forward direction – eastbound
- PHF – 0.95 for all movements
- 6% HV on major approaches
- 3% HV on minor approach
- Level terrain
- Arrival type 4 on mainline, 3 on side street
- 45 MPH speed limit on all approaches
- Cycle length – 80 seconds (actuated-coordinated)

Phase Approach	2 EBT	4 SBT	5 EBL	6 WBT
Phase Split	64.0	16.0	18.0	46.0
Yellow	4.4	4.0	3.0	4.3
Red	1.6	1.0	3.5	1.7
Min. Green	15.0	5.0	5.0	15.0
Recall	Min	Off	Off	Min



72



## Signalized Intersections



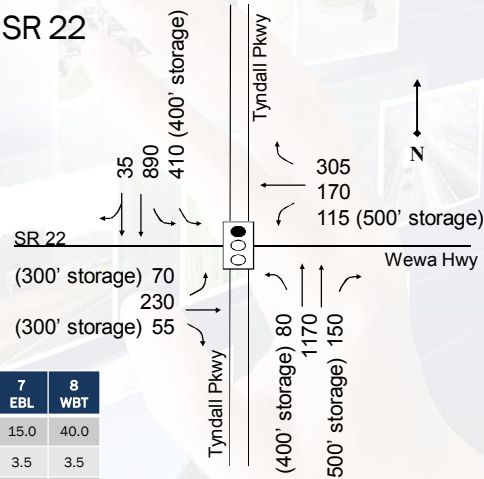
73

## Signalized Intersections

### Workshop #7: Tyndall Pkwy at SR 22 (Callaway, FL)

- Forward direction – northbound
- PHF – 0.90 for all movements
- Saturation – 1950 pc/h/ln
- 6% heavy vehicles for all movements
- Level terrain
- Arrival type 4 on mainline, 3 on side street
- 35 MPH speed limit on all approaches
- Cycle length – 160 seconds (coordinated)
- Protected RT at phases: 1, 3, 5
- E/W LT phases are protected + permitted
- Field-measured phase times are used

Phase Approach	1 SBL	2 NBT	3 WBL	4 EBT	5 NBL	6 SBT	7 EBL	8 WBT
Phase Split	30.0	75.0	15.0	40.0	30.0	75.0	15.0	40.0
Yellow	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
Red	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Min. Green	8	15	8	15	8	15	8	15
Recall	Off	Max	Off	Off	Off	Max	Off	Off



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## Signalized Intersections



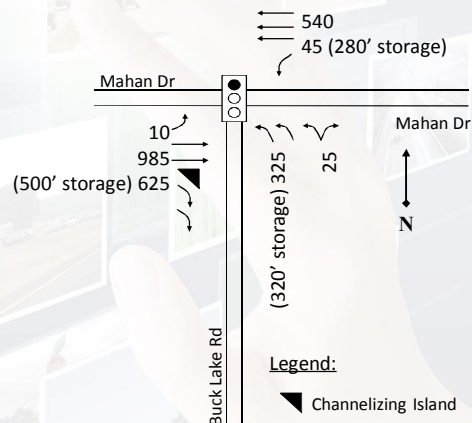
75

## Signalized Intersections

### Workshop #8: Mahan Dr at Buck Lake Rd (Tallahassee, FL)

- Forward direction – eastbound
- PHF – 0.92 for all approaches
- 8% heavy vehicles on all movements
- Level terrain
- Arrival type 3
- 45 MPH speed limit on all approaches
- Cycle length – 160 seconds
- Field-measured phase times are used

Phase Approach	1 WBL	2 EBT	3 NBL	6 WBT
Split	18.0	100.0	42.0	118.0
Yellow	3.0	4.1	3.0	4.1
Red	3.3	1.9	4.0	1.9
Min. Green	4.0	18.0	7.0	18.0
Recall	Off	Max	Off	Off



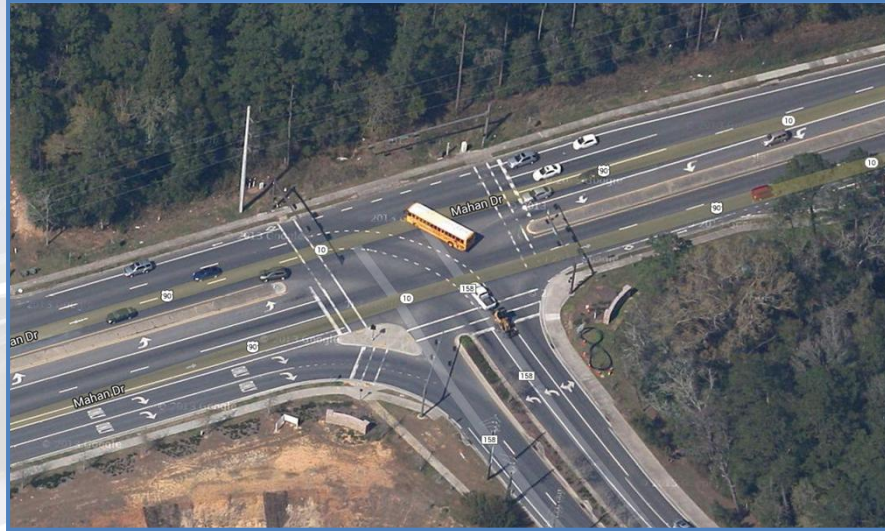
Legend:

Channelizing Island

76



## Signalized Intersections



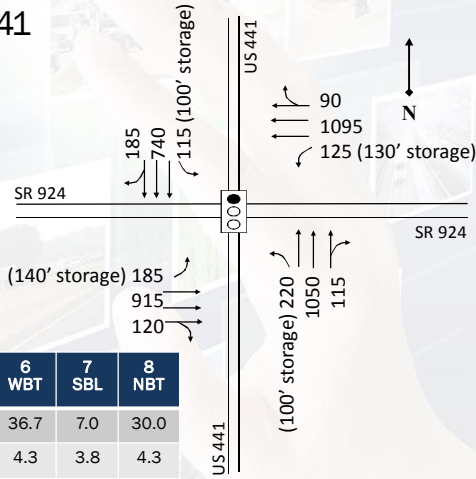
77

## Signalized Intersections

### Workshop #9: SR 924 at US 441 (Miami, FL)

- Forward direction – eastbound
- PHF – 0.96 for all approaches
- 3% heavy vehicles on all movements
- Level terrain
- Arrival type 3
- 40 MPH speed limit on all approaches
- Cycle length – 100 seconds (pre-timed)
- Uncoordinated intersection
- Protected + permissive for all lefts

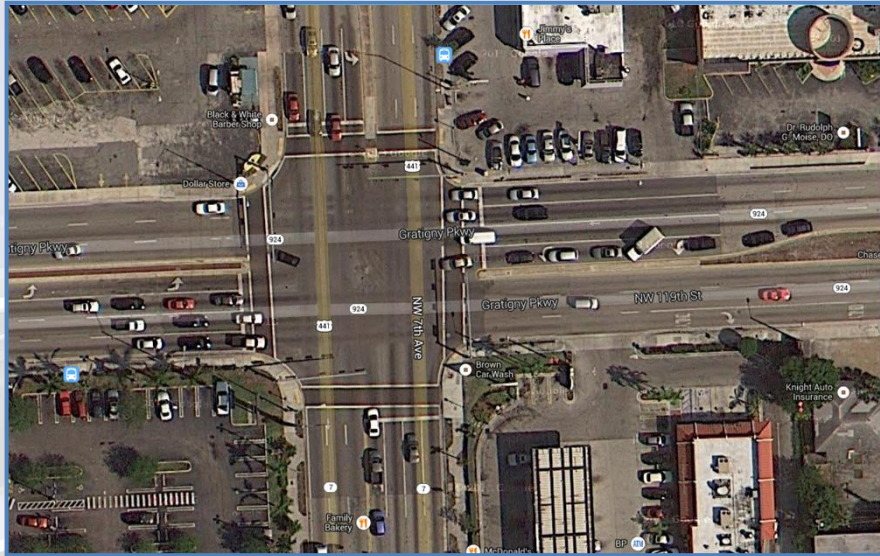
Phase Approach	1 WBL	2 EBT	3 NBL	4 SBT	5 EBL	6 WBT	7 SBL	8 NBT
Max. Green	7.0	36.7	7.0	30.0	7.0	36.7	7.0	30.0
Yellow	4.2	4.3	3.8	4.3	4.2	4.3	3.8	4.3
Red	0.0	1.3	0.0	1.4	0.0	1.3	0.0	1.4
Min. Green	5.0	7.0	5.0	7.0	5.0	7.0	5.0	7.0



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## Signalized Intersections



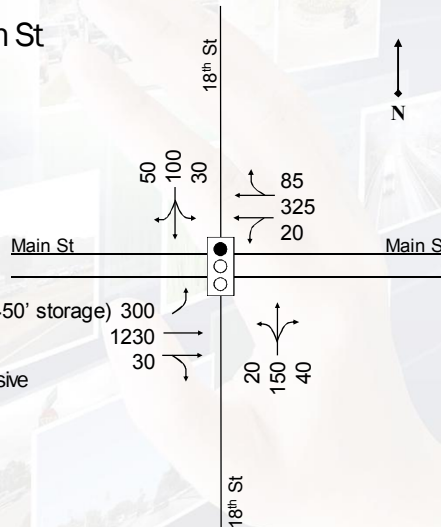
79

## Signalized Intersections

### Workshop #10: Main St at 18th St

- Forward direction – eastbound
- PHF – 0.90 for all movements
- 2% heavy vehicles for all movements
- Level terrain
- Arrival type 3
- 25 MPH speed limit for all approaches
- Cycle – 120 sec (pre-timed)
- 7 sec walk-time, 11-sec ped clearance
- 40 peds/hr crossing all approaches
- Split phasing on 18th St (NB is lag phase)
- Uncoordinated intersection
- EBL is protected/permissive, all others permissive
- Field-measured phase times are used

Phase Approach	2 EBT	5 EBL	6 WBT	8 NBT/SBT
Max. Green	54.5	18.5	30.5	24.5
Yellow	3.5	3.5	3.5	3.5
Red	2.0	2.0	2.0	2.0
Min. Green	4	4	4	4

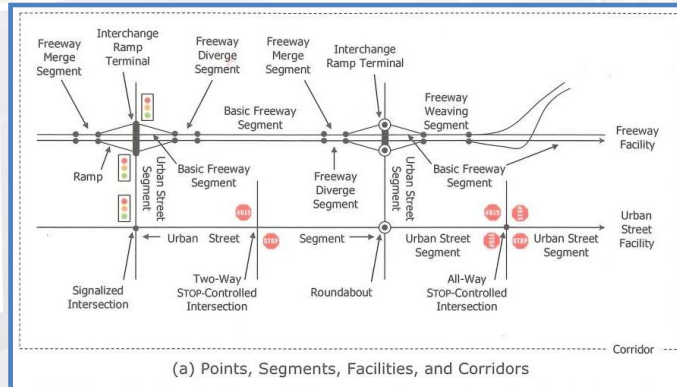


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## Day 2 – Interrupted Flow

- Signalized Intersections
- Urban Streets
  - Segments ◀
  - Facilities



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## Urban Streets - Segments

- Chapter 17 – HCM 2010
- New methodology for HCM 2010 (based on NCHRP 3-79)
- Multimodal
  - Automobile, pedestrian, bicycle, and transit
- One-way and two-way arterials/collectors
- Intersections on segment end points
  - Signalized and unsignalized
- Multiple Level of Service criteria
  - Automobiles (travel speed and volume/capacity)
  - Pedestrians (LOS score and space value)
  - Bicycle/Transit (LOS score)

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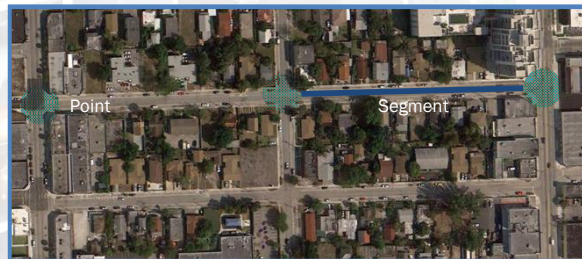


## Urban Streets - Segments

### Vocabulary

● **Point** – A boundary between links, usually a signalized intersection

● **Segment** – A portion of roadway extending from one point to another



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## Urban Streets - Segments

### HCM 2010 Exhibit 17-2 (LOS for Automobiles)

Travel Speed as a Percentage of Base Free-Flow Speed (%)	LOS by Volume-to-Capacity Ratio <sup>a</sup>	
	≤ 1.0	> 1.0
>85	A	F
>67-85	B	F
>50-67	C	F
>40-50	D	F
>30-40	E	F
≤ 30	F	F

Note: <sup>a</sup>Volume-to-capacity ratio of through movement at downstream boundary intersection.

### HCM 2010 Exhibit 17-3 (LOS for Pedestrians)

Pedestrian LOS Score	LOS by Average Pedestrian Space (ft <sup>2</sup> /p)					
	>60	>40-60	>24-40	>15-24	>8.0-15*	≤ 8.0*
≤ 2.00	A	B	C	D	E	F
>2.00-2.75	B	B	C	D	E	F
>2.75-3.50	C	C	C	D	E	F
>3.50-4.25	D	D	D	D	E	F
>4.25-5.00	E	E	E	E	E	F
>5.00	F	F	F	F	F	F

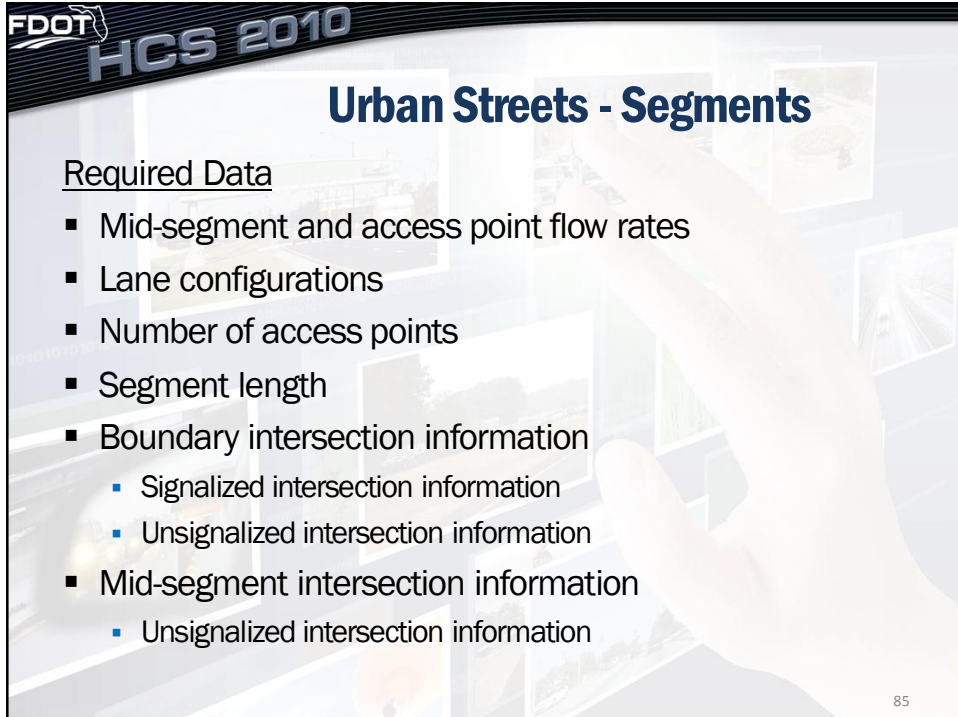
Note: \*In cross-flow situations, the LOS E/F threshold is 13 ft<sup>2</sup>/p.

### HCM 2010 Exhibit 17-4 (LOS Bicycle and Transit)

LOS	LOS Score
A	≤ 2.00
B	>2.00-2.75
C	>2.75-3.50
D	>3.50-4.25
E	>4.25-5.00
F	>5.00

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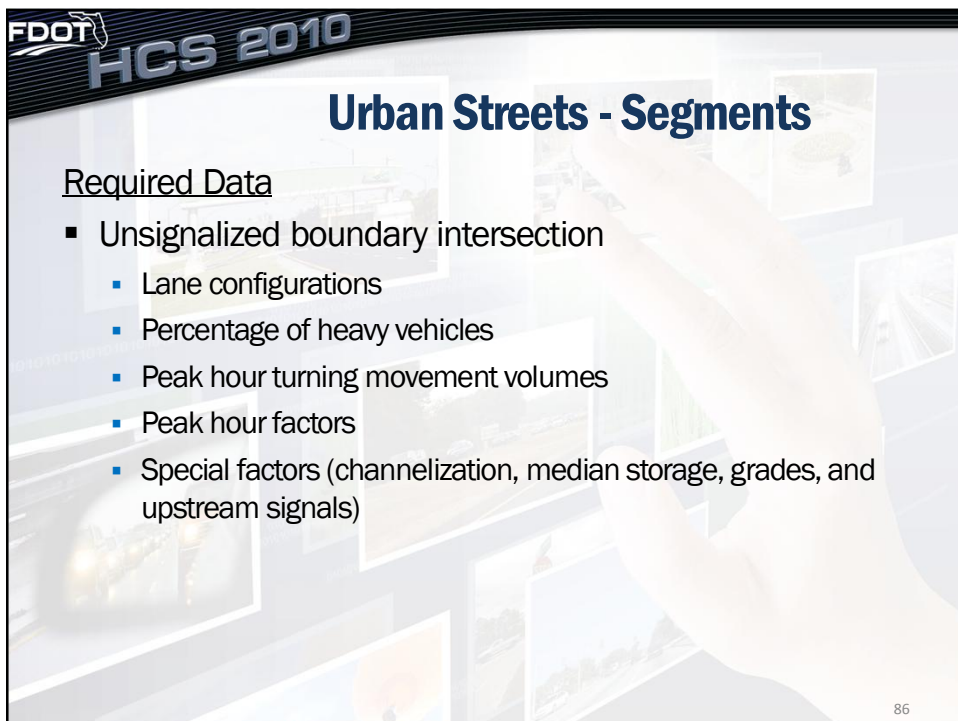
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**HCS 2010**

## Urban Streets - Segments

Required Data

- Mid-segment and access point flow rates
- Lane configurations
- Number of access points
- Segment length
- Boundary intersection information
  - Signalized intersection information
  - Unsignalized intersection information
- Mid-segment intersection information
  - Unsignalized intersection information

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**HCS 2010**

## Urban Streets - Segments

Required Data

- Unsignalized boundary intersection
  - Lane configurations
  - Percentage of heavy vehicles
  - Peak hour turning movement volumes
  - Peak hour factors
  - Special factors (channelization, median storage, grades, and upstream signals)

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## Urban Streets - Segments

Required Data

- Signalized boundary intersection
  - Lane configurations
  - Percentage of heavy vehicles
  - Peak hour turning movement volumes
  - Peak hour factor or 15-minute traffic volumes
  - Traffic signal phasing
  - Traffic signal timing parameters

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## Urban Streets - Segments

Required Data (non-automobile)

- Pedestrian
  - Pedestrian flow rate
  - Sidewalk information
  - Distance to nearest signal-controlled crossing
- Bicycle
  - On-street parking occupied
  - Lane configurations
  - Pavement condition rating
- Transit
  - Dwell time, transit frequency
  - Area type (CBD)
  - Transit stop information

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## Urban Streets - Segments

### Limitations

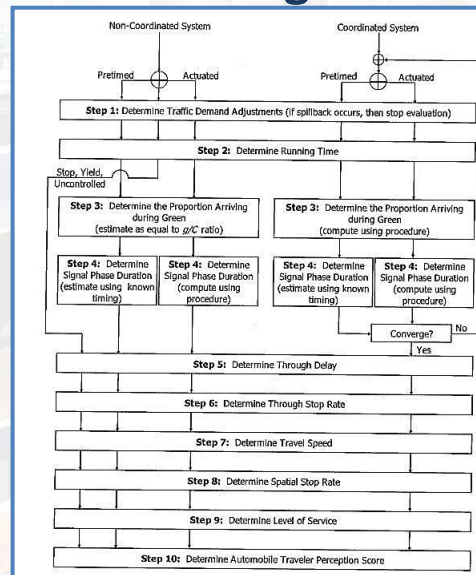
- Automobile
  - On-street parking activity
  - Capacity constraints between intersections
  - Queuing at the downstream boundary intersection
  - Shared-use lanes (Automobile/Bicycle)
- Non-automobile
  - Segments bound by All-Way Stop/Roundabouts
  - Mid-segment unsignalized crosswalks
  - Points of high volume pedestrian access to a sidewalk
  - Points where a high volume of vehicles cross a sidewalk

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## Urban Streets - Segments

### Methodology

- Automobile Mode  
(Exhibit 17-8)



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## Urban Streets - Segments

### Methodology

- Pedestrian Mode (Exhibit 17-15)**
- Transit Mode (Exhibit 17-22)**
- Bicycle Mode (Exhibit 17-20)**

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## Urban Streets - Segments

### Example #5: Main St between 15th St and 17th St NB

- Forward direction – eastbound
- 4-lane undivided roadway
- 25 MPH speed limit
- Upstream width EB/WB – 60 feet
- Segment default values
  - Cycle length: 120 sec
  - Minimum green: 4 sec
  - Yellow change: 3.5 sec
  - Red clearance: 2 sec
- Access Point
  - Volumes and geometry as shown
  - 17th Street southbound
  - PHF = 0.90

92

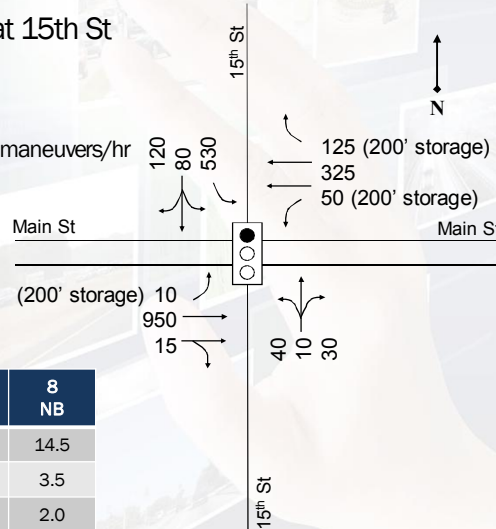


## Urban Streets - Segments

### Example #5 (cont): Main St at 15th St

- PHF - 0.90 for all movements
- 2% heavy vehicles for all movements
- EB and WB - 5 buses/hr
- On-street parking on WB approach - 10 maneuvers/hr
- 20 peds/hr crossing all approaches
- Arrival type 3
- Cycle length - 90 sec (pre-timed)
- Split phasing (NB lag)
- Uncoordinated intersection
- Field-measured phase times
- 7 sec walk-time, 11-sec ped clearance

Phase Approach	2 EB	4 SB	6 WB	8 NB
Max. Green	29.5	29.5	29.5	14.5
Yellow	3.5	3.5	3.5	3.5
Red	2.0	2.0	2.0	2.0
Min. Green	4	4	4	4



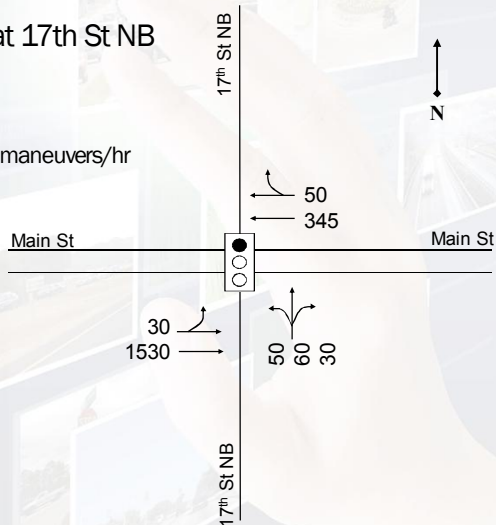
93

## Urban Streets - Segments

### Example #5 (cont): Main St at 17th St NB

- PHF - 0.90 for all movements
- 2% heavy vehicles for all movements
- EB and WB - 5 buses/hr
- On-street parking on WB approach - 10 maneuvers/hr
- 20 peds/hr crossing all approaches
- Arrival type 3
- Cycle length - 90 sec (pre-timed)
- Uncoordinated intersection
- Field-measured phase times
- 7 sec walk-time, 11-sec ped clearance

Phase Approach	2 EB	4 NB	6 WB
Max. Green	62.5	16.5	62.5
Yellow	3.5	3.5	3.5
Red	2.0	2.0	2.0
Min. Green	4	4	4



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## Urban Streets - Segments

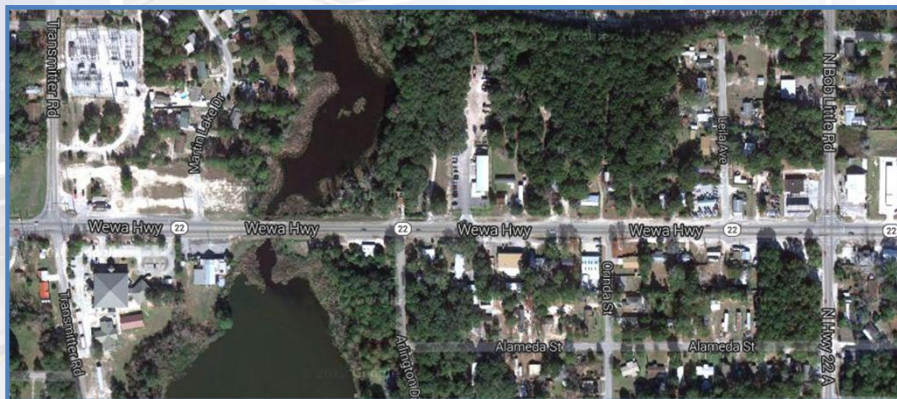
Workshop #11: SR 22 between Transmitter Rd and Bob Little Rd  
(Springfield, FL)

- Forward direction – eastbound
- 2-lane undivided mainline roadway
- 45 MPH speed limit
- Upstream width EB/WB – 40 feet
- Segment default values:
  - Cycle length: 60 sec
  - Minimum green: 2 sec
  - Yellow change: 3 sec
  - Red clearance: 1 sec
- Access Points
  - Volumes and geometry as shown
  - Assume turn lanes with 200' storage from SR 22
  - PHF = 0.90

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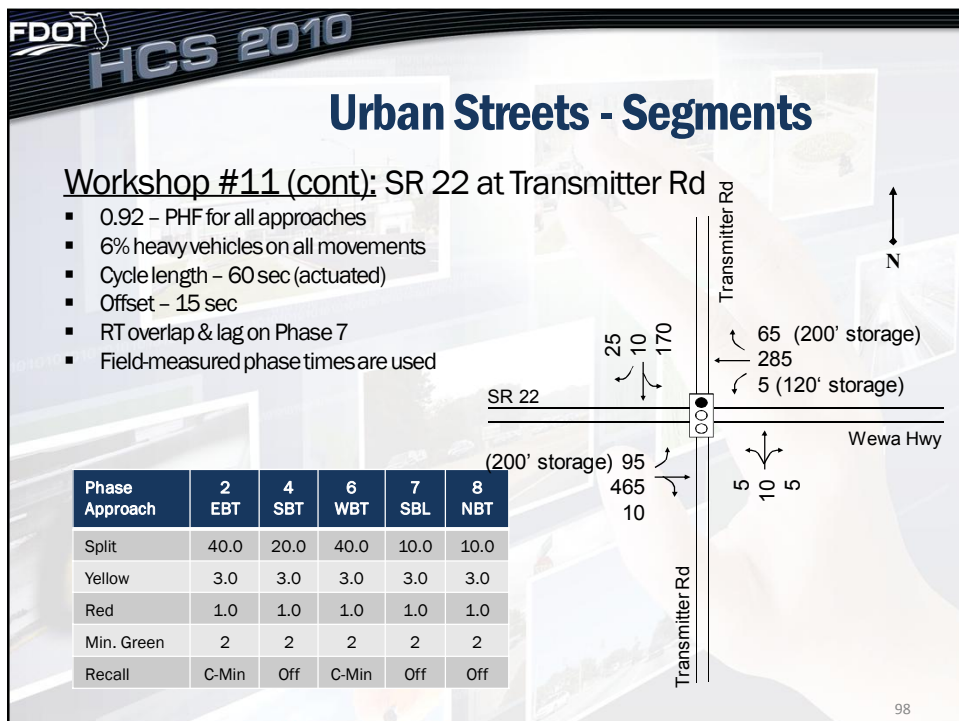
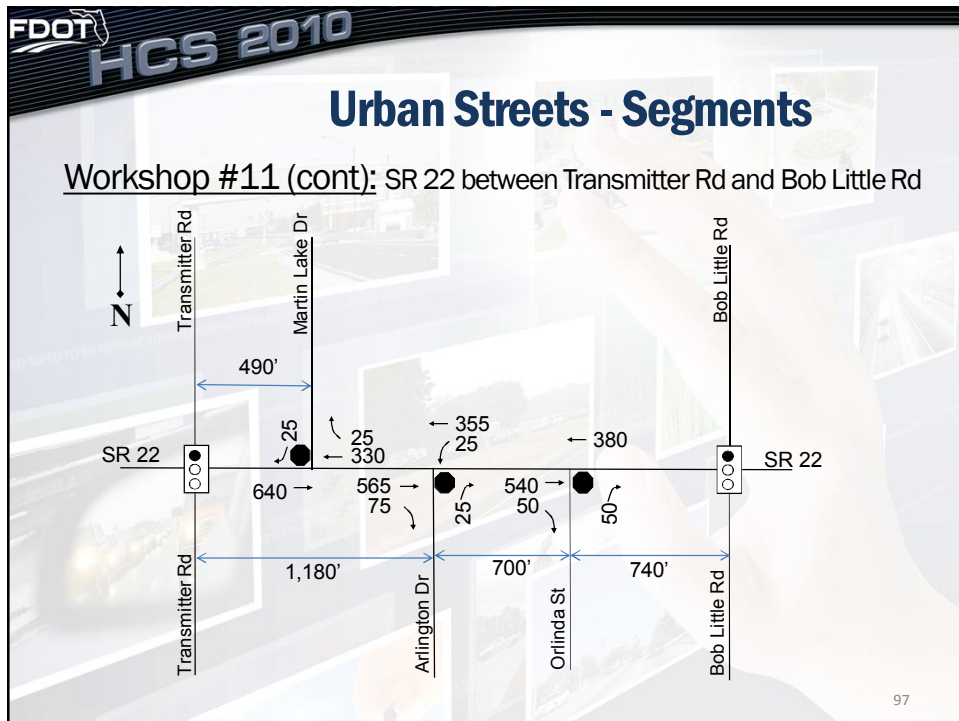
## Urban Streets - Segments

Workshop #11: SR 22 between Transmitter Rd & Bob Little Rd  
(Springfield, FL)



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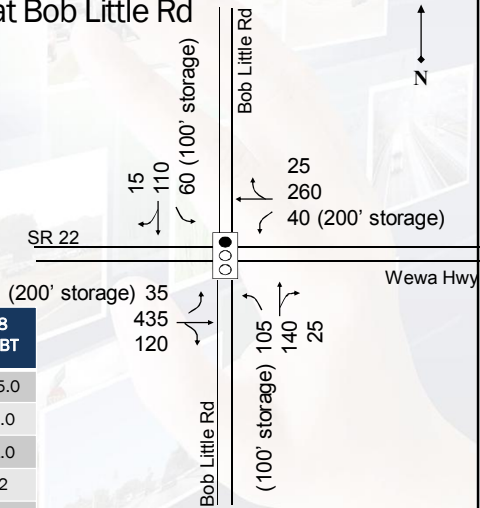


## Urban Streets - Segments

### Workshop #11 (cont): SR 22 at Bob Little Rd

- 0.92 - PHF for all approaches
- 6% heavy vehicles on all movements
- Cycle length - 60 sec (actuated)
- Offset - 35 sec
- Lag phase: Phase 3
- Field-measured phase times are used

Phase Approach	2 EBT	3 NBL	4 SBT	6 WBT	8 NBT
Split	35.0	15.0	10.0	35.0	25.0
Yellow	3.0	3.0	3.0	3.0	3.0
Red	1.0	1.0	1.0	1.0	1.0
Min. Green	2	2	2	2	2
Recall	C-Min	Off	Off	C-Min	Off



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## Day 2 - Interrupted Flow

- Signalized Intersections
- Urban Streets
  - Segments
  - Facilities

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## Urban Streets - Facilities

- Chapter 16 – HCM 2010
- New methodology for HCM 2010
- Multimodal
  - Automobile, pedestrian, bicycle, and transit
- One-way and two-way arterials/collectors
- Multiple level of service criteria
  - Travel speed (all modes)
  - Stop rate (automobile)
  - Perception score (pedestrian/bicycle/transit)
  - Pedestrian (space)

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## Urban Streets - Facilities

- Exhibit 16-4 HCM 2010 (LOS for Automobiles)

Travel Speed as a Percentage of Base Free-Flow Speed (%)	LOS by Critical Volume-to-Capacity Ratio <sup>a</sup>	
	≤ 1.0	> 1.0
>85	A	F
>67–85	B	F
>50–67	C	F
>40–50	D	F
>30–40	E	F
≤30	F	F

Note: <sup>a</sup> The critical volume-to-capacity ratio is based on consideration of the through movement volume-to-capacity ratio at each boundary intersection in the subject direction of travel. The critical volume-to-capacity ratio is the largest ratio of those considered.

- Exhibit 16-5 HCM 2010 (LOS for Pedestrians)

Pedestrian LOS Score	LOS by Average Pedestrian Space ( $f^2/p$ )					
	>60	>40-60	>24-40	>15-24	>8.0-15*	≤ 8.0*
≤2.00	A	B	C	D	E	F
>2.00-2.75	B	B	C	D	E	F
>2.75-3.50	C	C	C	D	E	F
>3.50-4.25	D	D	D	D	E	F
>4.25-5.00	E	E	E	E	E	F
>5.00	F	F	F	F	F	F

Note: <sup>a</sup> In cross-flow situations, the LOS E-F threshold is 13 ft<sup>2</sup>/p.

- Exhibit 16-6 HCM 2010 (LOS for Bicycle and Transit)

LOS	LOS Score
A	$\leq 2.00$
B	>2.00-2.75
C	>2.75-3.50
D	>3.50-4.25
E	>4.25-5.00
F	>5.00

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## Urban Streets - Facilities

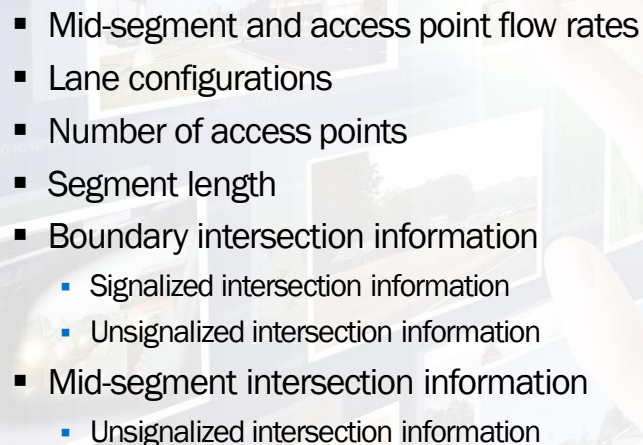
- Exhibit 16-7 *HCM 2010* (Input Data Requirements)

Data Category	Location	Input Data Element	Basis
Geometric Design	Segment	Segment length	Segment
Other	Segment	Analysis period duration	Facility
Performance Measures	Boundary intersection	Volume-to-capacity ratio	Through-movement group
	Segment	Base free-flow speed Travel speed	Segment Segment

Notes: Through-movement group = one value for the segment through movement at the downstream boundary intersection (inclusive of any turn movements in a shared lane).  
Segment = one value or condition for each segment and direction of travel on the facility.  
Facility = one value or condition for the facility.

## Urban Streets - Facilities

### Required Data

- 
- Mid-segment and access point flow rates
  - Lane configurations
  - Number of access points
  - Segment length
  - Boundary intersection information
    - Signalized intersection information
    - Unsignalized intersection information
  - Mid-segment intersection information
    - Unsignalized intersection information





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## Urban Streets - Facilities

Required Data

- Unsignalized boundary intersection
  - Lane configurations
  - Percentage of heavy vehicles
  - Peak hour turning movement volumes
  - Peak hour factors
  - Special factors (channelization, median storage, grades, upstream signals)

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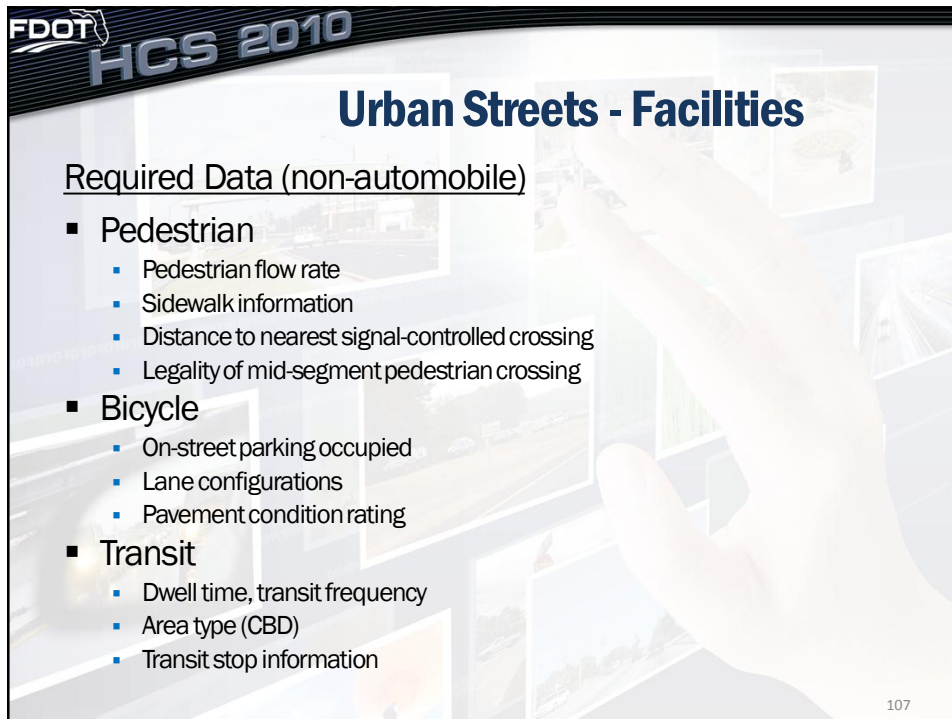
## Urban Streets - Facilities

Required Data

- Signalized boundary intersection
  - Lane configurations
  - Percentage of heavy vehicles
  - Peak hour turning movement volumes
  - Peak hour factor or 15-minute traffic volumes
  - Traffic signal phasing
  - Traffic signal timing parameters

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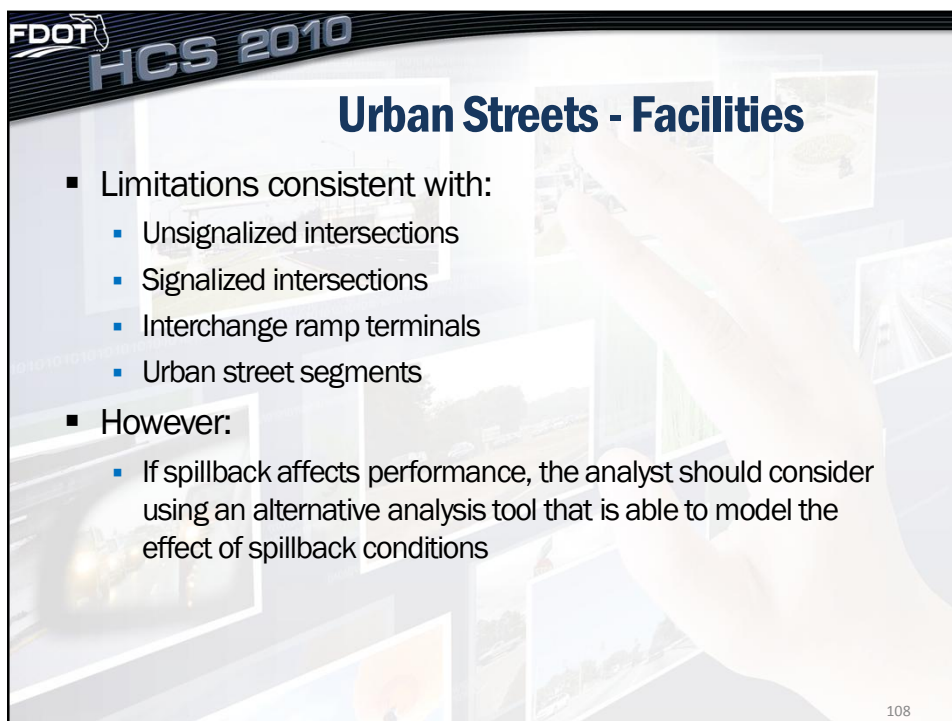
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**HCS 2010**

## Urban Streets - Facilities

Required Data (non-automobile)

- **Pedestrian**
  - Pedestrian flow rate
  - Sidewalk information
  - Distance to nearest signal-controlled crossing
  - Legality of mid-segment pedestrian crossing
- **Bicycle**
  - On-street parking occupied
  - Lane configurations
  - Pavement condition rating
- **Transit**
  - Dwell time, transit frequency
  - Area type (CBD)
  - Transit stop information

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## Urban Streets - Facilities

- Limitations consistent with:
  - Unsignalized intersections
  - Signalized intersections
  - Interchange ramp terminals
  - Urban street segments
- However:
  - If spillback affects performance, the analyst should consider using an alternative analysis tool that is able to model the effect of spillback conditions

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## Urban Streets - Facilities

- Methodology
- Automobile Mode (Exhibit 16-9)
- Pedestrian Mode (Exhibit 16-10)\*
- Bicycle Mode (Exhibit 16-12)\*
- Transit Mode (Exhibit 16-13) \*

**Step 1:** Determine Base Free-Flow Speed

**Step 2:** Determine Travel Speed

**Step 3:** Determine Spatial Stop Rate

**Step 4:** Determine Automobile LOS

**Step 1:** Determine Pedestrian Space

**Step 2:** Determine Pedestrian Travel Speed

**Step 3:** Determine Pedestrian LOS Score

**Step 4:** Determine Pedestrian LOS

**Step 1:** Determine Bicycle Travel Speed

**Step 2:** Determine Bicycle LOS Score

**Step 3:** Determine Bicycle LOS

**Step 1:** Determine Transit Travel Speed

**Step 2:** Determine Transit LOS Score

**Step 3:** Determine Transit LOS

**\*Specific to one side of street**

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**FDOT HCS 2010**

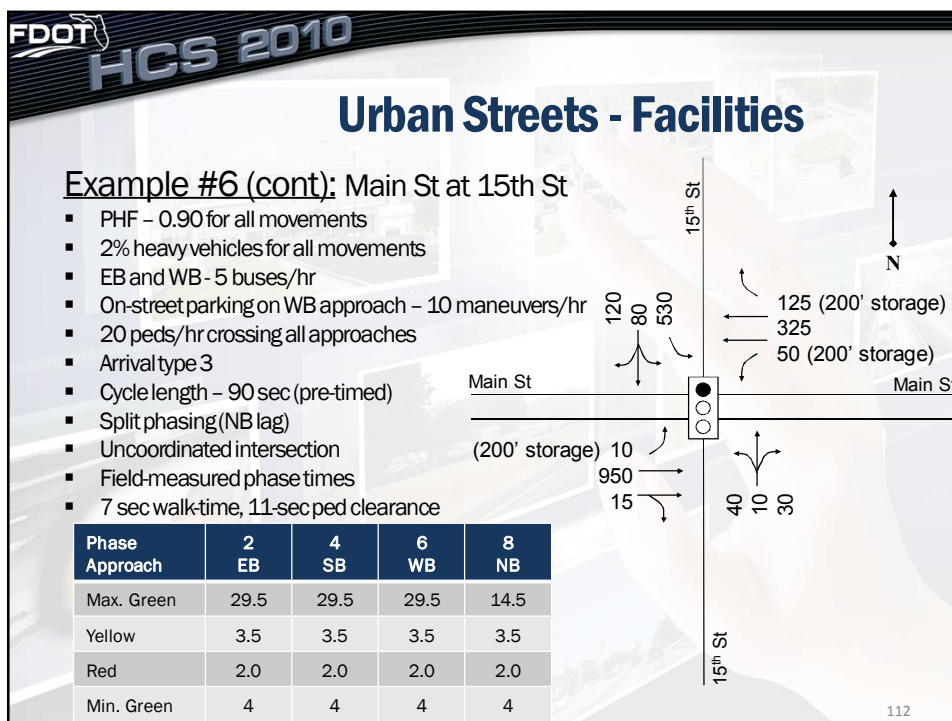
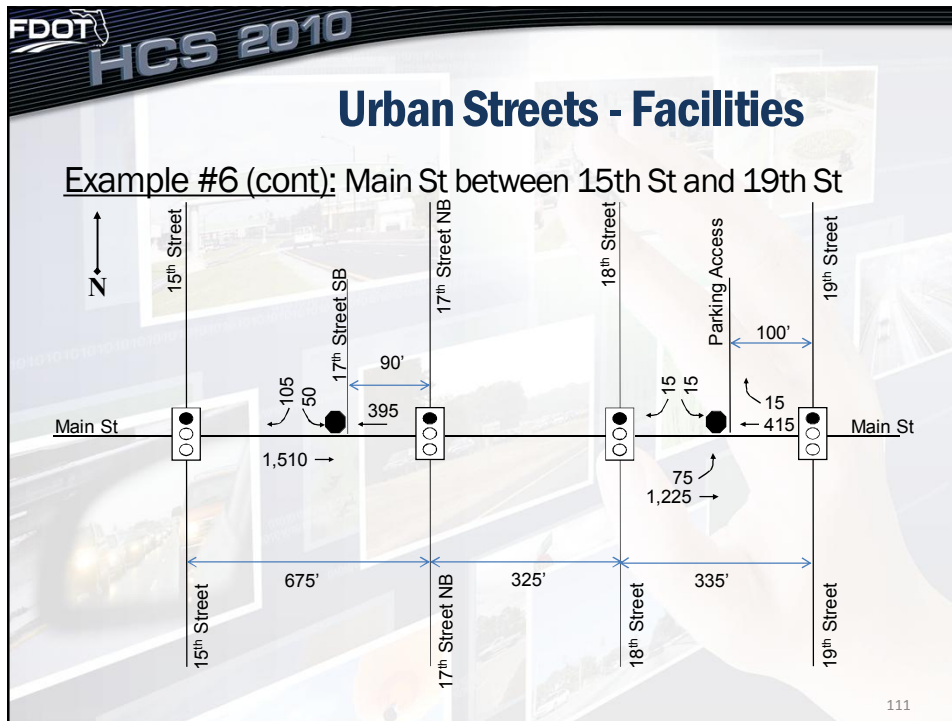
## Urban Streets - Facilities

**Example #6:** Main St between 15th St and 19th St

- Forward direction – eastbound
- 4-lane undivided roadway
- 25 MPH speed limit
- Upstream width EB/WB – 60 feet
- Segment default values
  - Cycle length: 90 sec
  - Minimum green: 4 sec
  - Yellow change: 3.5 sec
  - Red clearance: 2 sec
- Access Points
  - 17th St SB (585' east of 15th St)
  - Parking Access (235' east of 18th St)
  - PHF = 0.90
- Field-measured phase times

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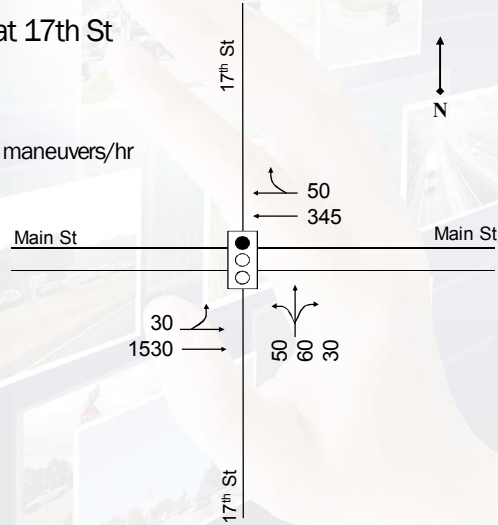


## Urban Streets - Facilities

### Example #6 (cont): Main St at 17th St

- PHF – 0.90 for all movements
- 2% heavy vehicles for all movements
- EB and WB - 5 buses/hr
- On-street parking on WB approach – 10 maneuvers/hr
- 20 peds/hr crossing all approaches
- Arrival type 3
- Cycle length – 90 sec (pre-timed)
- Uncoordinated intersection
- Field-measured phase times
- 7 sec walk-time, 11-sec ped clearance

Phase Approach	2 EB	4 NB	6 WB
Max. Green	62.5	16.5	62.5
Yellow	3.5	3.5	3.5
Red	2.0	2.0	2.0
Min. Green	4	4	4



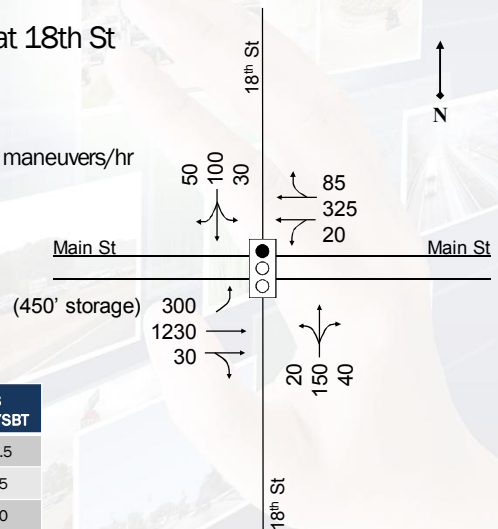
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## Urban Streets - Facilities

### Example #6 (cont): Main St at 18th St

- PHF – 0.90 for all movements
- 2% heavy vehicles for all movements
- EB and WB - 5 buses/hr
- On-street parking on WB approach – 10 maneuvers/hr
- 40 peds/hr crossing all approaches
- Arrival type 3
- Cycle length – 120 sec (pre-timed)
- Split phasing (NB lag)
- Uncoordinated intersection
- Field-measured phase times
- 7 sec walk-time, 11-sec ped clearance

Phase Approach	2 EBT	5 EBL	6 WBT	8 NBT/SBT
Max. Green	54.5	18.5	30.5	24.5
Yellow	3.5	3.5	3.5	3.5
Red	2.0	2.0	2.0	2.0
Min. Green	4	4	4	4



114

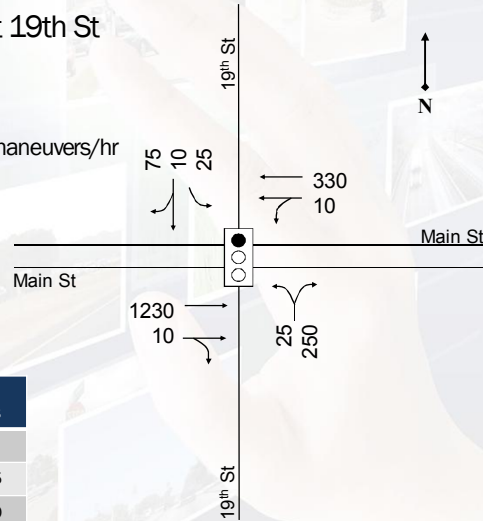


## Urban Streets - Facilities

### Example #6 (cont): Main St at 19th St

- PHF – 0.90 for all movements
- 2% heavy vehicles for all movements
- EB and WB – 5 buses/hr
- On-street parking on WB approach – 10 maneuvers/hr
- 10 peds/hr crossing all approaches
- Arrival type 3
- Cycle – 90 sec (pre-timed)
- Split phasing (SB lag)
- Uncoordinated intersection
- Field-measured phase times
- 7 sec walk-time, 11-sec ped clearance

Phase Approach	2 EB	4 SB	6 WB	8 NB
Max. Green	32	18	32	23
Yellow	3.5	3.5	3.5	3.5
Red	2.0	2.0	2.0	2.0
Min. Green	4	4	4	4



115

## Urban Streets - Facilities

### Workshop #12: SR 924 (Gratigny Pkwy) between 32nd Ave and 17th Ave (Miami, FL)

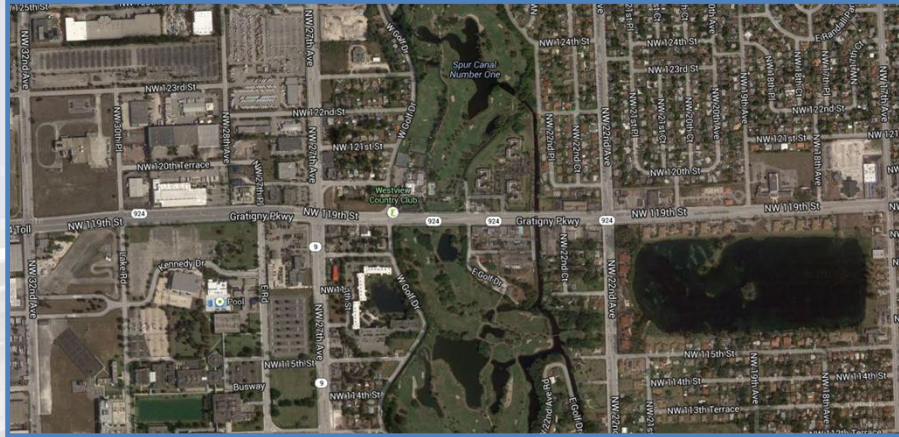
- 8-lane divided roadway with 30' median
- Upstream width EB/WB – 100 feet
- Cycle length = 100 sec for all intersections



116



## Urban Streets - Facilities

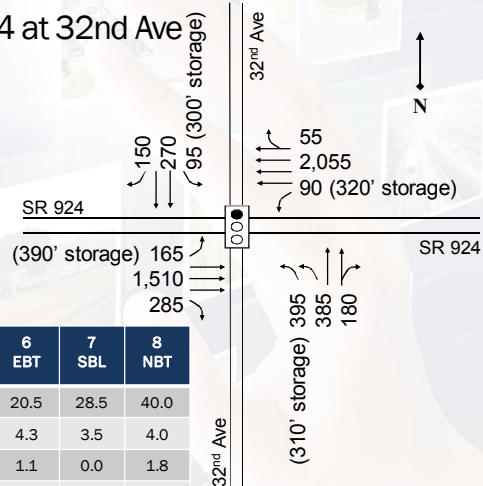


117

## Urban Streets - Facilities

### Workshop #12 (cont): SR 924 at 32nd Ave

- 0.92 - PHF for all approaches
- 5% HV on mainline approaches
- 14% HV on minor approaches
- 40 MPH speed limit on all approaches
- Cycle length - 100 sec (actuated)
- Offset - 28 sec
- EB, WB, & SBLT phases protected + permissive
  - NB LT phase protected only



Phase Approach	1 EBL	2 WBT	3 NBL	4 SBT	5 WBL	6 EBT	7 SBL	8 NBT
Split	11.0	20.5	28.5	40.0	11.0	20.5	28.5	40.0
Yellow	5.0	4.3	3.5	4.0	5.0	4.3	3.5	4.0
Red	0.0	1.1	0.0	1.8	0.0	1.1	0.0	1.8
Min. Green	5	5	5	7	5	5	5	7
Recall	Off	C-Min	Off	Off	Off	C-Min	Off	Off

118

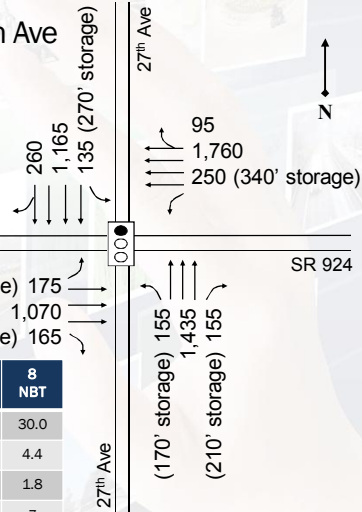


## Urban Streets - Facilities

### Workshop #12 (cont): SR 924 at 27th Ave

- 0.96 - PHF for all approaches
- 5% HV on mainline approaches
- 7% HV on minor approaches
- 40 MPH speed limit on mainline approaches
- 45 MPH speed limit on minor approaches
- Cycle length - 100 sec (actuated)
- Offset - 50 sec
- All LT phases are protected + permissive

Phase Approach	1 EBL	2 WBT	3 NBL	4 SBT	5 WBL	6 EBT	7 SBL	8 NBT
Split	15.8	38.8	15.4	30.0	15.8	38.8	15.4	30.0
Yellow	4.8	4.0	4.4	4.4	4.8	4.0	4.4	4.4
Red	0.0	1.8	0.0	1.8	0.0	1.8	0.0	1.8
Min. Green	5	5	5	7	5	5	5	7
Recall	Off	C-Min	Off	Off	Off	C-Min	Off	Off



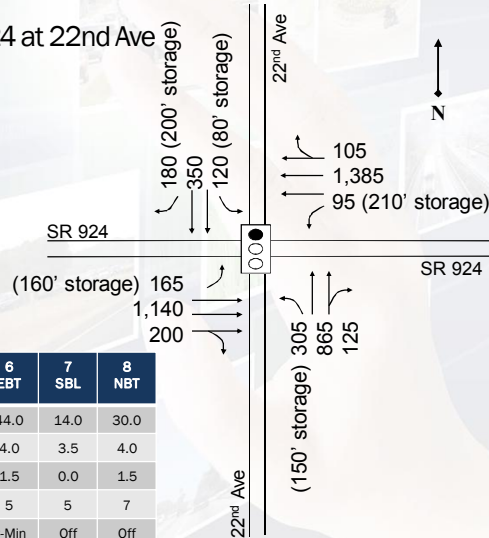
119

## Urban Streets - Facilities

### Workshop #12 (cont): SR 924 at 22nd Ave

- 0.93 - PHF for all approaches
- 3% HV on mainline approaches
- 2% HV on minor approaches
- 40 MPH speed limit on all approaches
- Cycle length - 100 sec (actuated)
- Offset - 99 sec
- N/S LT phases protected + permissive
  - E/W LT phases protected only

Phase Approach	1 EBL	2 WBT	3 NBL	4 SBT	5 WBL	6 EBT	7 SBL	8 NBT
Split	12.0	44.0	14.0	30.0	12.0	44.0	14.0	30.0
Yellow	3.5	4.0	3.5	4.0	3.5	4.0	3.5	4.0
Red	0.0	1.5	0.0	1.5	0.0	1.5	0.0	1.5
Min. Green	5	5	5	7	5	5	5	7
Recall	Off	C-Min	Off	Off	Off	C-Min	Off	Off



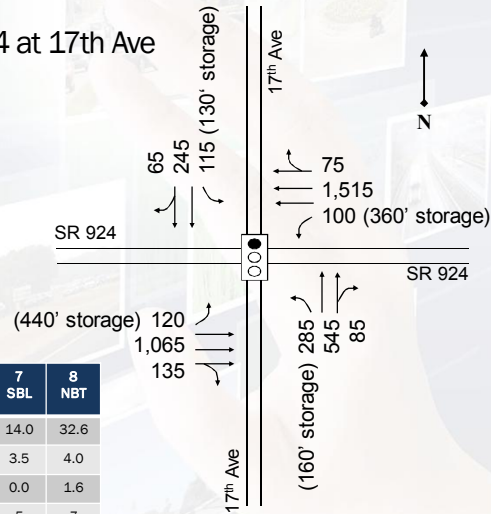
120



## Urban Streets - Facilities

### Workshop #12 (cont): SR 924 at 17th Ave

- 0.88 - PHF for all approaches
- 3% heavy vehicles on all movements
- 40 MPH speed limit on all approaches
- Cycle length - 100 sec (actuated)
- Offset - 68 sec
- All LT phases protected + permissive



Phase Approach	1 WBL	2 EBT	3 NBL	4 SBT	5 EBL	6 WBT	7 SBL	8 NBT
Split	11.0	42.4	14.0	32.6	11.0	42.4	14.0	32.6
Yellow	3.5	4.0	3.5	4.0	3.5	4.0	3.5	4.0
Red	0.0	1.1	0.0	1.6	0.0	1.1	0.0	1.6
Min. Green	5	5	5	7	5	5	5	7
Recall	Off	C-Min	Off	Off	Off	C-Min	Off	Off

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## Day 3 - Uninterrupted Flow (Mostly)

- Interchanges
- Freeways
  - Basic segments
  - Weaving segments
  - Merge and diverge segments
  - Freeway facilities
- Multi-lane highway segments
- Two-lane highway segments

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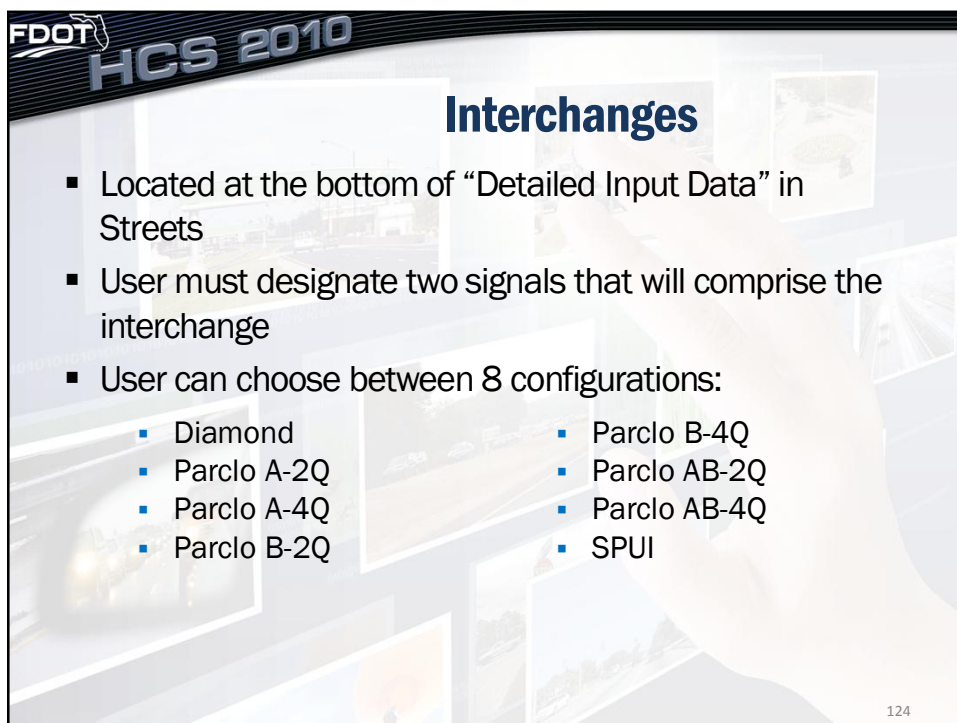


**FDOT**  
**HCS 2010**

## Housekeeping

- Breaks
  - 10:00 – 10:15 am
  - Lunch 11:30 – 1:00 pm
  - 2:30 – 2:45 pm

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**FDOT**  
**HCS 2010**

## Interchanges

- Located at the bottom of “Detailed Input Data” in Streets
- User must designate two signals that will comprise the interchange
- User can choose between 8 configurations:
  - Diamond
  - Parclo A-2Q
  - Parclo A-4Q
  - Parclo B-2Q
  - Parclo B-4Q
  - Parclo AB-2Q
  - Parclo AB-4Q
  - SPUI

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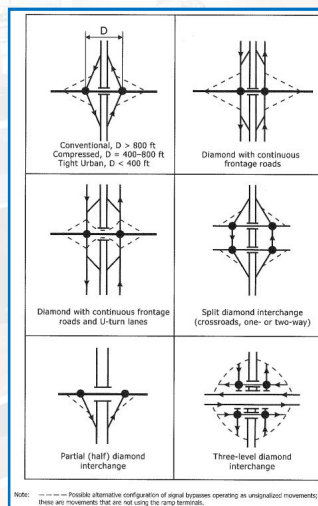
## Interchanges

- “Parclo” is short for Partial Cloverleaf configuration
- Letters A, B, or AB refer to relative quadrant locations of ramps
- Numbers 2 or 4 refer to number of Quadrants
- “SPUI” is an acronym for Single-Point Urban Interchange; operates with only one intersection

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## Interchanges

- *HCM 2010*  
Exhibit 22-1



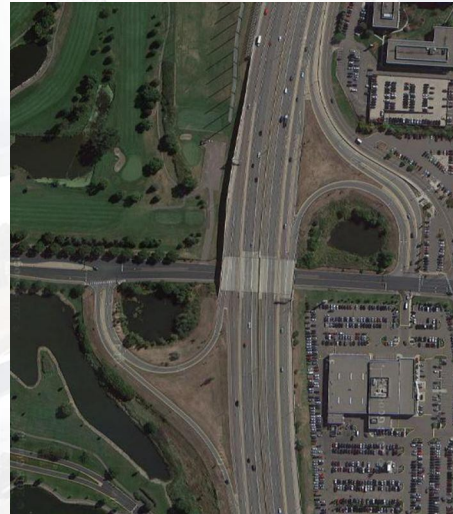
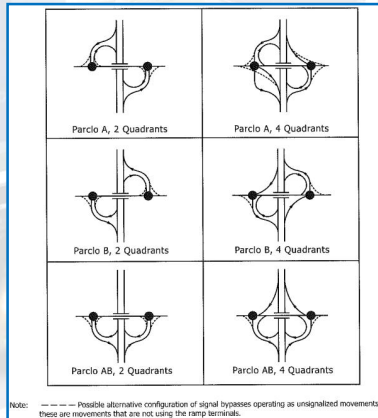
126



## Interchanges

### Configuration types

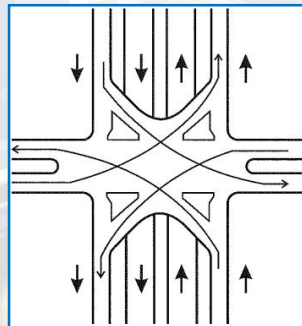
#### ■ HCM 2010 Exhibit 22-2



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## Interchanges

#### ■ HCM 2010 Exhibit 22-3



### Single-Point Urban Interchange

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## Interchanges

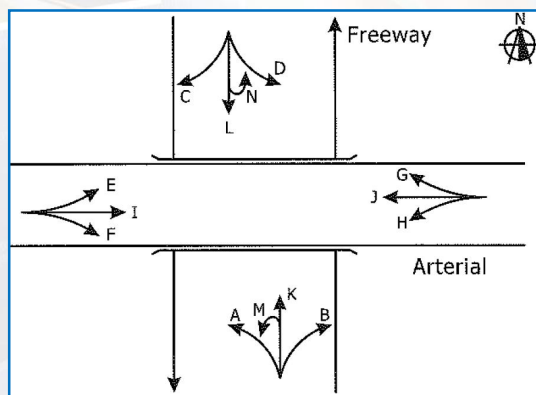


Single-Point Urban Interchange

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## Interchanges

- Every possible Origin-Destination (O-D) movement within a configuration is assigned a letter A – N
- *HCM 2010*  
Exhibit 22-5



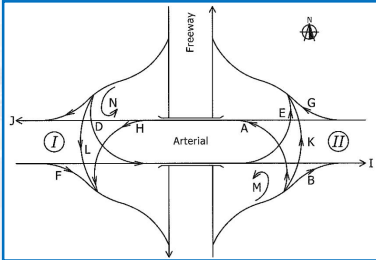
130



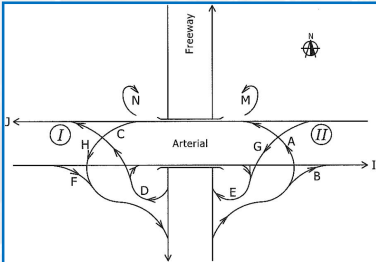
**FDOT HCS 2010**

## Interchanges

- HCM 2010 Exhibit 22-6



- HCM 2010 Exhibit 22-7

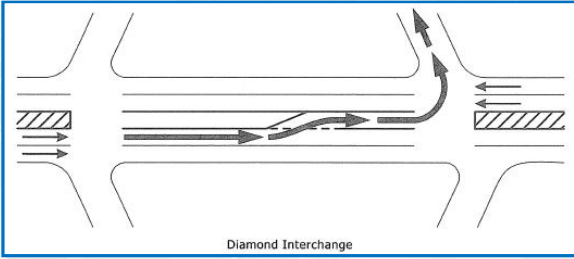


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**FDOT HCS 2010**

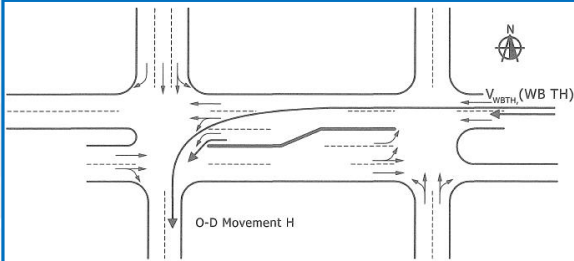
## Interchanges

- HCM 2010 Exhibit 22-8



Diamond Interchange

- HCM 2010 Exhibit 22-10



O-D Movement H

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## Interchanges

- Each movement has a unique Demand (veh/h), Delay (s/veh) and corresponding LOS

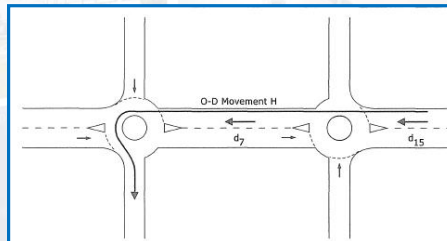
### HCM 2010 Exhibit 22-11

Control Delay (s/veh)	O-D LOS		
	$v/c < 1$ and $R_Q < 1$ for Every Lane Group	$v/c > 1$ for Any Lane Group	$R_Q > 1$ for Any Lane Group
≤15	A	F	F
>15-30	B	F	F
>30-55	C	F	F
>55-85	D	F	F
>85-120	E	F	F
>120	F	F	F

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## Interchanges

- HCM 2010 Exhibit 22-12 - Interchanges with Roundabouts



- HCM 2010 Exhibit 22-13 - Interchanges with Roundabouts

Control Delay (s/veh)	O-D LOS		
	$v/c < 1$ and $R_Q < 1$ for All Approaches	$v/c > 1$ for Any Approach	$R_Q > 1$ for Any Approach
≤15	A	F	F
>15-25	B	F	F
>25-35	C	F	F
>35-50	D	F	F
>50-75	E	F	F
>75	F	F	F

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## Interchanges

- A new formatted report titled “Interchange Report” provides an overview of how the interchange is performing
- Additional input data is required by the user
  - Segment length, ft
  - U-turn volume, veh/h
  - Turn radius, ft
- Refer to HCM Chapter 22 for more information on how to choose the appropriate configuration

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## Interchanges

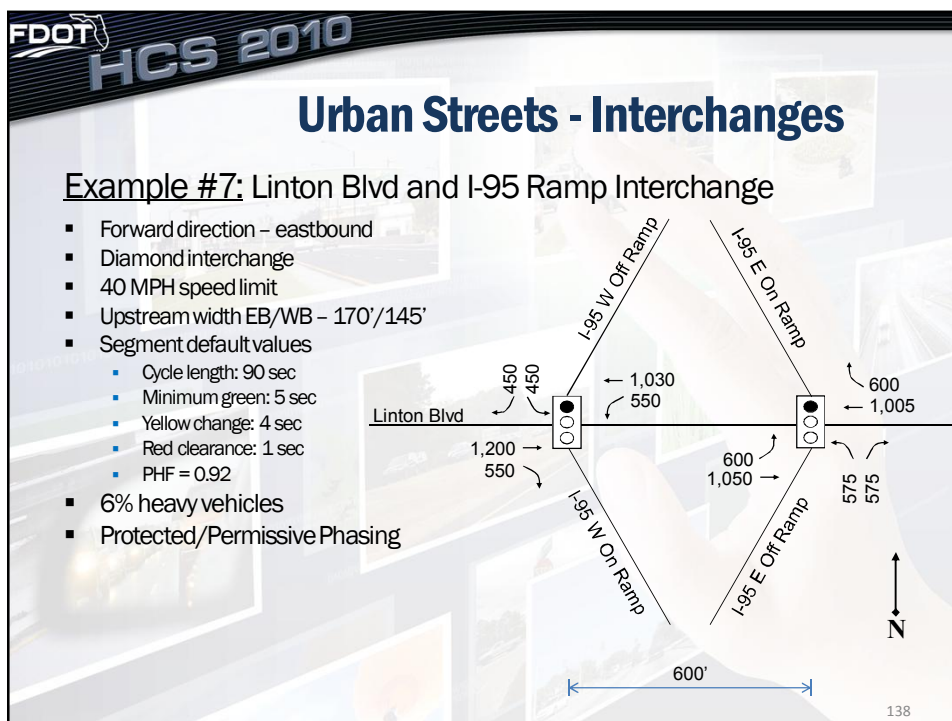
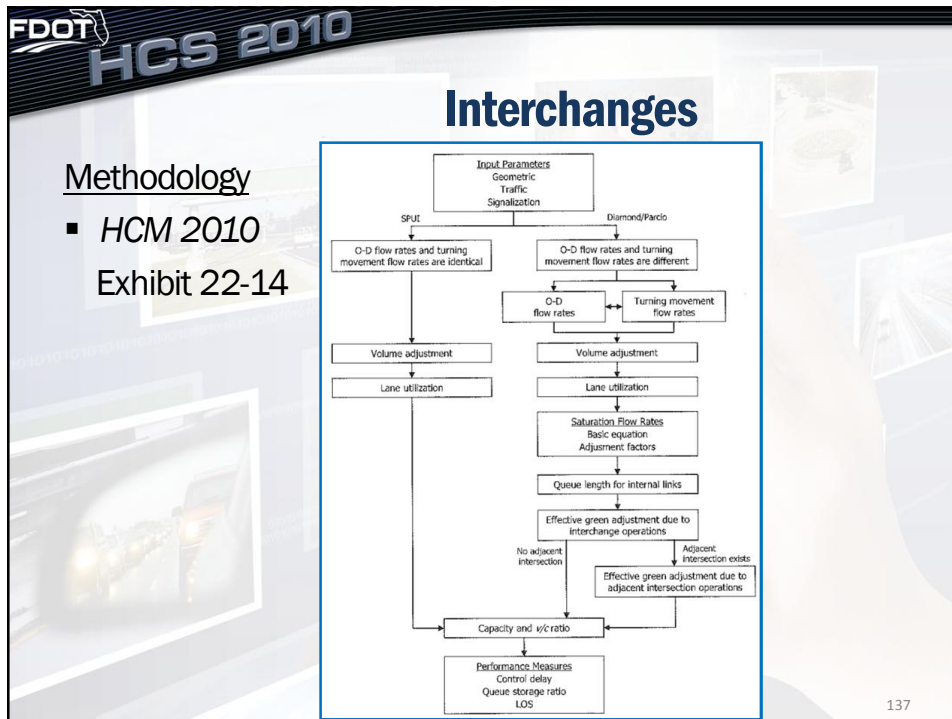
### Required Data

- HCM 2010  
Exhibit 22-15

Type of Condition	Parameter
Geometric conditions	<p>Area type</p> <p>Number of lanes (<math>N</math>)</p> <p>Average lane width (<math>W</math>, ft)</p> <p>Grade (<math>G</math>, %)</p> <p>Existence of exclusive left- or right-turn lanes</p> <p>Length of storage for each lane group (<math>L_w</math>, ft)</p> <p>Distance corresponding to the internal storage between the two intersections in the interchange (<math>D</math>, ft)</p> <p>Distances corresponding to the internal storage between interchange intersections and adjacent closely spaced intersections (ft)</p> <p>Turning radii for all turning movements (ft)</p>
Traffic conditions	<p>Demand volume by O-D or turning movement (<math>V</math>, veh/h)</p> <p>Right-turn-on-red flow rates</p> <p>Base saturation flow rate (<math>s_b</math>, pc/hg/ln)</p> <p>Peak hour factor (<math>PHF</math>)</p> <p>Percent heavy vehicles (<math>HV</math>, %)</p> <p>Approach pedestrian flow rates (<math>V_{ped}</math>, ped/h)</p> <p>Approach bicycle flow rates (<math>v_b</math>, bicycles/h)</p> <p>Local bus stopping rate (<math>N_b</math>, buses/h)</p> <p>Parking activity (<math>P_{av}</math>, maneuvers/h)</p> <p>Arrival type (<math>A_T</math>)</p> <p>Upstream filtering adjustment factor</p> <p>Approach speed (<math>S_a</math>, mi/h)</p>
Signalization conditions	<p>Type of signal control</p> <p>Phase sequence</p> <p>Cycle length (if appropriate) (<math>C</math>, s)</p> <p>Green times (if appropriate) (<math>G</math>, s)</p> <p>Yellow-plus-all-red change-and-clearance interval (intergreen) (<math>Y</math>, s)</p> <p>Offset (if appropriate)</p> <p>Maximum, minimum green, passage times, phase recall (for actuated control)</p> <p>Pedestrian push button</p> <p>Minimum pedestrian green (<math>G_{ps}</math>, s)</p> <p>Phase plan</p>

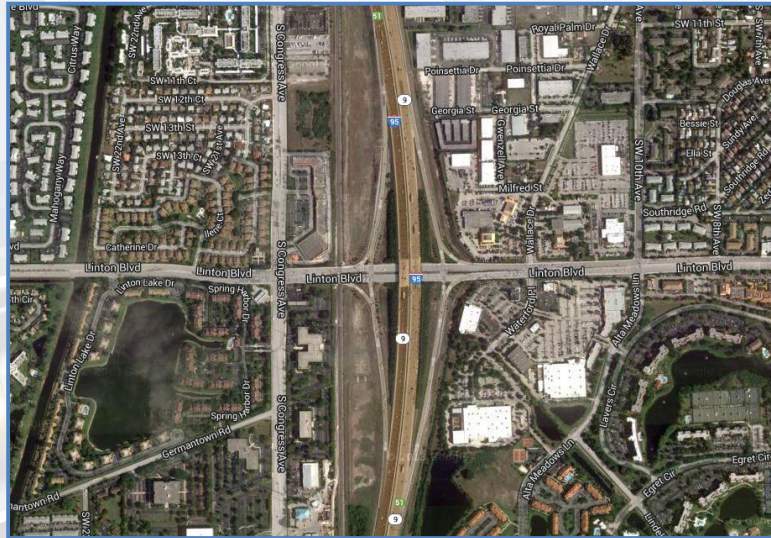
136







## Urban Streets - Interchanges



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## Urban Streets - Interchanges

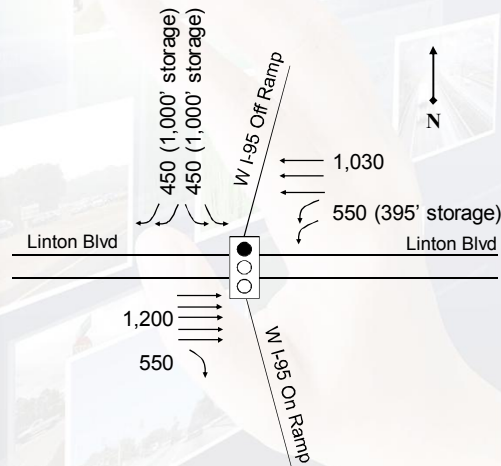
### Example #7 (cont): Linton Blvd and W I-95 Ramp

- PHF - 0.92 for all movements
- 6% heavy vehicles for all movements
- No pedestrians
- Arrival type 4 EB/WB, 3 SB
- Cycle length - 90 sec. (Actuated)
- Coordinated intersection

Phase Approach	1 WBL	2 EB	4 SB	6 WB
Split	10	55	25	65
Yellow	4.0	4.0	4.0	4.0
Red	1.0	1.0	1.0	1.0
Min. Green	5	5	5	5
Recall Mode	Off	Min	Off	Min

#### Interchange Inputs

Movement	EBR	WBL	SBL	SBR
Turn Radius	250	125	100	150



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## Urban Streets - Interchanges

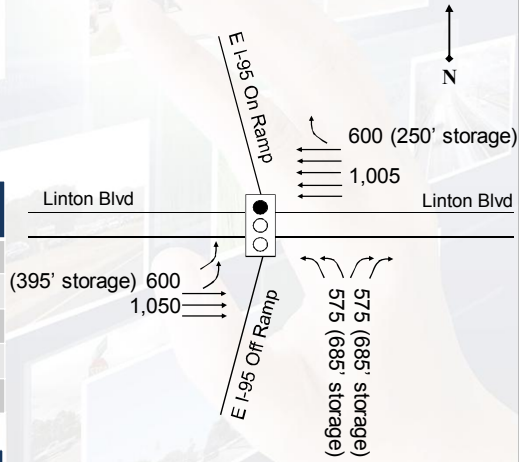
### Example #7 (cont): Linton Blvd and E I-95 Ramp

- PHF = 0.92 for all movements
- 6% heavy vehicles for all movements
- No pedestrians
- Arrival type 4 EB/WB, 3 NB
- Cycle length = 90 sec. (Actuated)
- Coordinated intersection = 10s offset

Phase Approach	2 EB	5 EBL	6 WB	8 NB
Split	65	10	55	25
Yellow	4.0	4.0	4.0	4.0
Red	1.0	1.0	1.0	1.0
Min. Green	5	5	5	5
Recall Mode	Min	Off	Min	Off

#### Interchange Inputs

Movement	EBL	WBR	NBL	NBR
Turn Radius	100	175	100	175



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## Urban Streets - Interchanges

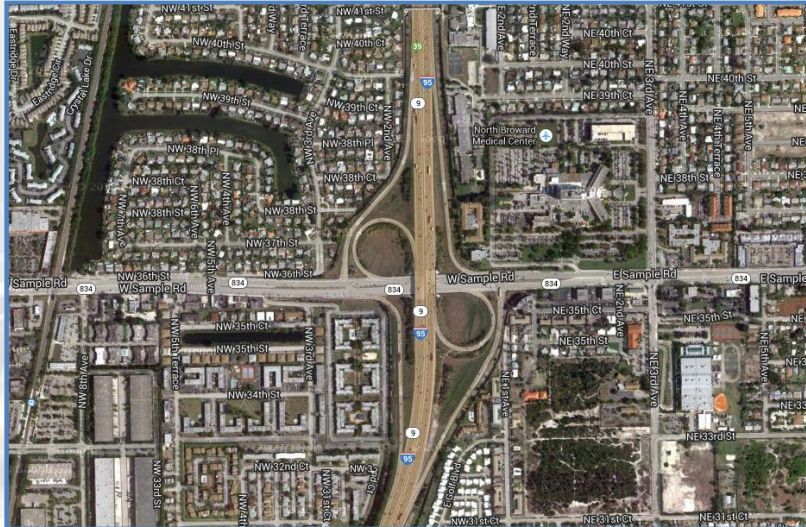
### Workshop #13: Sample Rd and I-95 Ramp Interchange

- Forward direction = eastbound
- Parclo A-4 Quadrant interchange
- 45 MPH speed limit
- Upstream width EB/WB = 110'/135'
- Segment default values
  - Cycle length: 90 sec
  - Minimum green: 5 sec
  - Yellow change: 4 sec
  - Red clearance: 1 sec
  - PHF = 0.92
- 6% heavy vehicles

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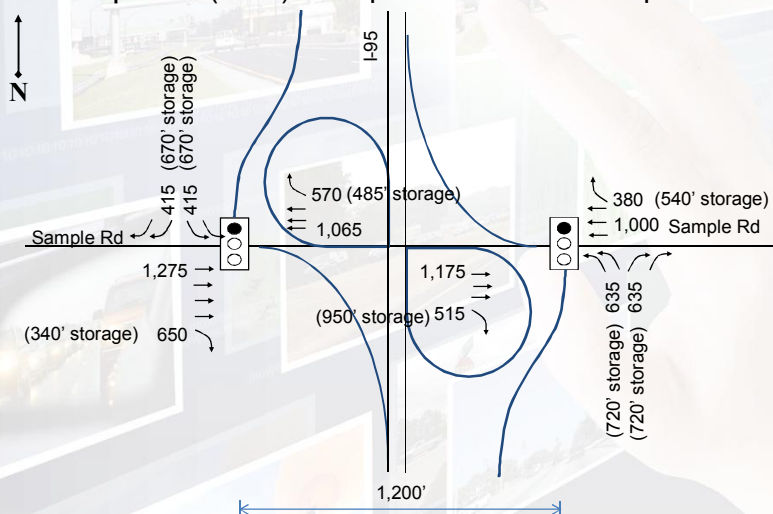
## Urban Streets - Interchanges



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## Urban Streets - Interchanges

### Workshop #13 (cont): Sample Rd and I-95 Ramp Interchange



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## Urban Streets - Interchanges

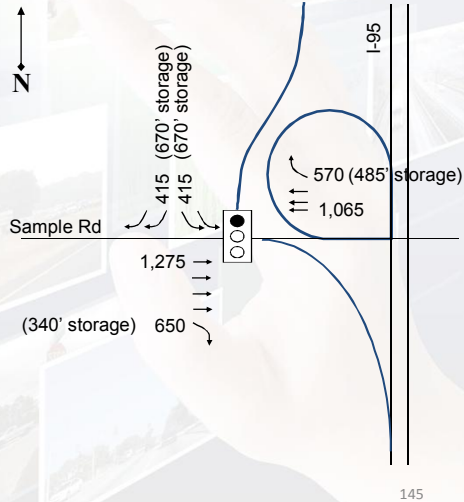
### Workshop #13 (cont): Sample Rd and W I-95 Ramp

- PHF - 0.92 for all movements
- 6% heavy vehicles for all movements
- No pedestrians
- Arrival type 4 EB/WB, 3 SB
- Cycle length - 90 sec. (Actuated)
- Coordinated intersection

Phase Approach	2 EB	4 SB	6 WB
Split	60	30	60
Yellow	4.0	4.0	4.0
Red	1.0	1.0	1.0
Min. Green	5	5	5
Recall Mode	Min	Off	Min

#### Interchange Inputs

Movement	EBR	WBR	SBL	SBR
Turn Radius	225	250	300	300



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## Urban Streets - Interchanges

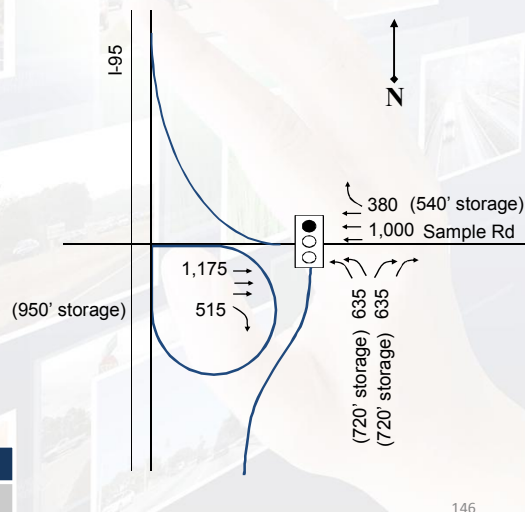
### Workshop #13 (cont): Sample Rd and E I-95 Ramp

- PHF - 0.92 for all movements
- 6% heavy vehicles for all movements
- No pedestrians
- Arrival type 4 EB/WB, 3 NB
- Cycle length - 90 sec. (Actuated)
- Coordinated intersection - 18s offset

Phase Approach	2 EB	6 WB	8 NB
Split	55	55	35
Yellow	4.0	4.0	4.0
Red	1.0	1.0	1.0
Min. Green	5	5	5
Recall Mode	Min	Min	Off

#### Interchange Inputs

Movement	EBR	WBR	NBL	NBR
Turn Radius	250	200	350	350



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**FDOT**  
**HCS 2010**

## Day 3 – Uninterrupted Flow (Mostly)

- Interchanges
- Freeways
  - Basic segments ◀
  - Weaving segments
  - Merge and diverge segments
  - Freeway facilities
- Multi-lane highway segments
- Two-lane highway segments

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**FDOT**  
**HCS 2010**

## Basic Freeway Segments

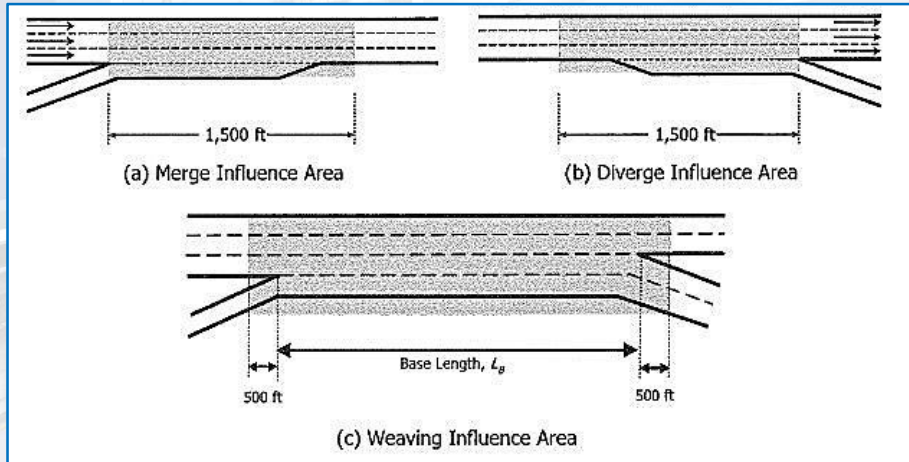
- Chapter 11 – *HCM 2010*
- Freeway segments without influence from
  - Merging (1,500 feet downstream)
  - Diverging (1,500 feet upstream)
  - Weaving (500 feet upstream/downstream)
- Uniform segments under base conditions
  - Good weather/visibility
  - No incidents/work zone activity/pavement deterioration
- Level-of-service criteria
  - Density (passenger cars/mile/lane)
- New in 2010: New speed-flow curve for 75 mph

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## Basic Freeway Segments

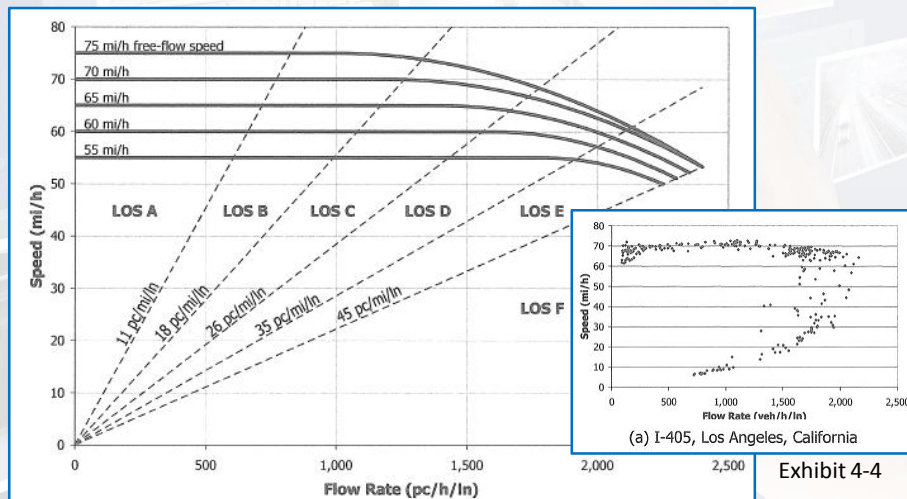
- HCM 2010 Exhibit 10-1



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## Basic Freeway Segments

- HCM 2010 Exhibit 11-6

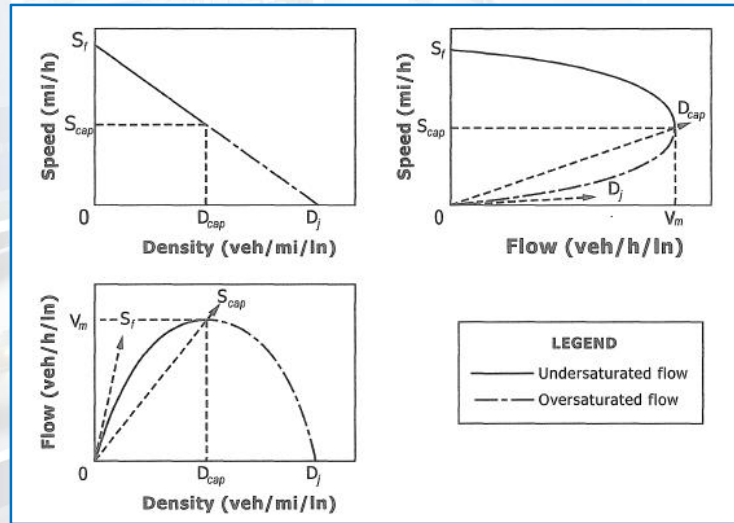


150



## Speed, Flow, Density Relationships

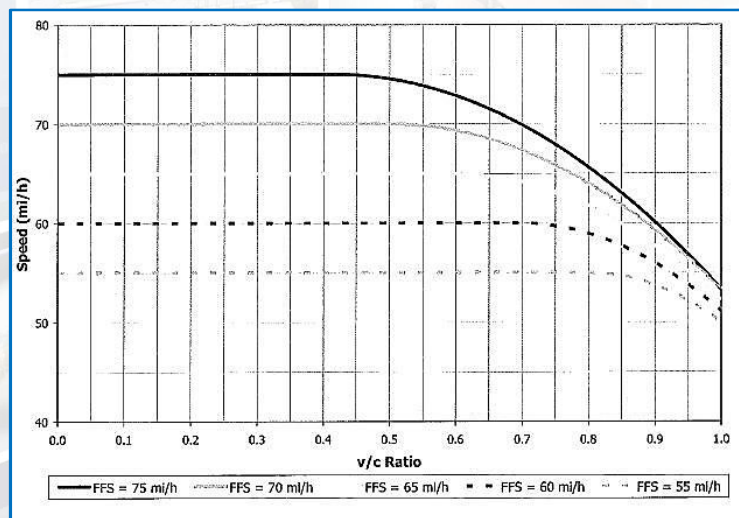
■ HCM 2010 Exhibit 4-3



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## Basic Freeway Segments

■ HCM 2010 Exhibit 11-14



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## Basic Freeway Segments

- HCM 2010 Exhibit 11-5 (LOS for Automobiles)

LOS	Density (pc/mi/ln)
A	≤11
B	>11–18
C	>18–26
D	>26–35
E	>35–45
F	Demand exceeds capacity >45

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## Basic Freeway Segments

### Required Data

- Number of lanes, lane widths and lateral clearance
- Free-flow speed (FFS)
- Ramp density (ramps/mile)
  - On and off ramps (one direction) 3 miles upstream and 3 miles downstream of segment midpoint, divided by 6 miles
- Terrain
  - Level, rolling, mountainous, or length/percent grade
- Demand data
  - AADT, K factor and directional distribution (planning level)
  - Peak hour volumes and PHF
  - Percentage of heavy vehicles
  - Driver population factor

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## Basic Freeway Segments

### Limitations

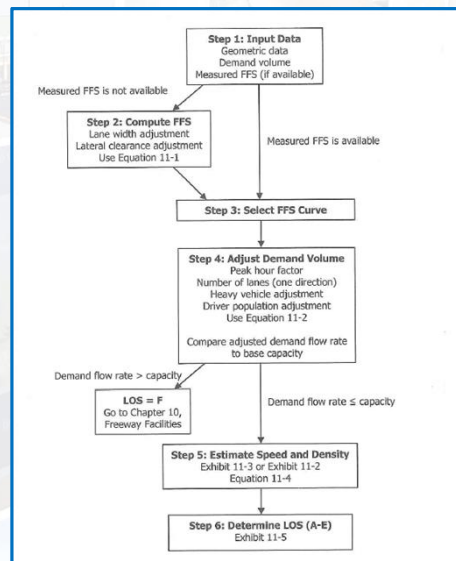
- Special lanes and lane control
  - HOV lanes, truck lanes, climbing lanes and lane changing restrictions
- Free-flow speed (FFS) below 55 mph and above 75 mph
- Influence from downstream queues
- Posted speed limit and enforcement
- Impacts of Intelligent Transportation Systems (ITS)
- Operations in construction zones, near toll plazas and extended bridge/tunnel segments
- Oversaturated conditions

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## Basic Freeway Segments

### Methodology

- HCM 2010  
Exhibit 11-7



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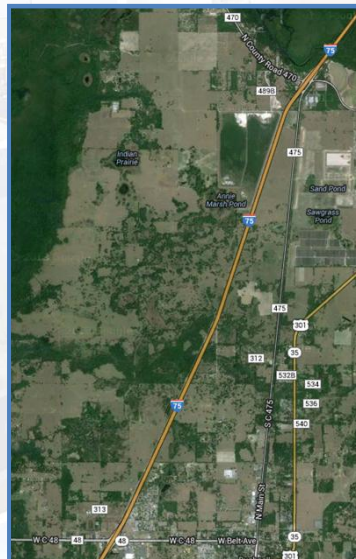
## Basic Freeway Segments

### Example #8: I-75 NB from CR 470 to FL-48 (Bushnell, FL)

- Select "Operations" Analysis, utilize Planning Data
  - AADT – 37,700 veh/day
  - K – 10%
  - D – 56%
- PHF – 0.88
- 2-lane freeway
- Level terrain
- 20% trucks and buses
- 75.4 MPH base free-flow speed
  - Lane width – 12.0 ft
  - Right-side lateral clearance – 6.0 ft
  - Total ramp density – 4 ramps/6 mi = 0.66 ramps/mi

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## Basic Freeway Segments



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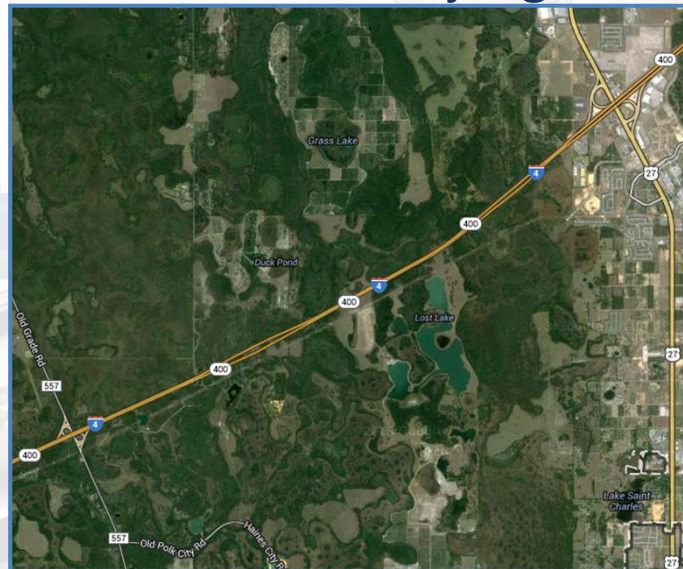
## Basic Freeway Segments

### Workshop #14: I-4 EB from CR 557 to US-27 (Haines City, FL)

- Select “Operations” Analysis, utilize Planning Data
  - AADT – 77,500 veh/day
  - K – 9% (FDOT “standard K”)
  - D – 52%
- 3-lane freeway
- PHF – 0.92
- Level terrain
- 14% trucks and buses
- 75.4 MPH base free-flow speed
  - Lane width – 11.0 ft
  - Right-side lateral clearance – 3.0 ft
  - Total ramp density – 0 ramps/6 mi = 0.0 ramps/mi

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## Basic Freeway Segments



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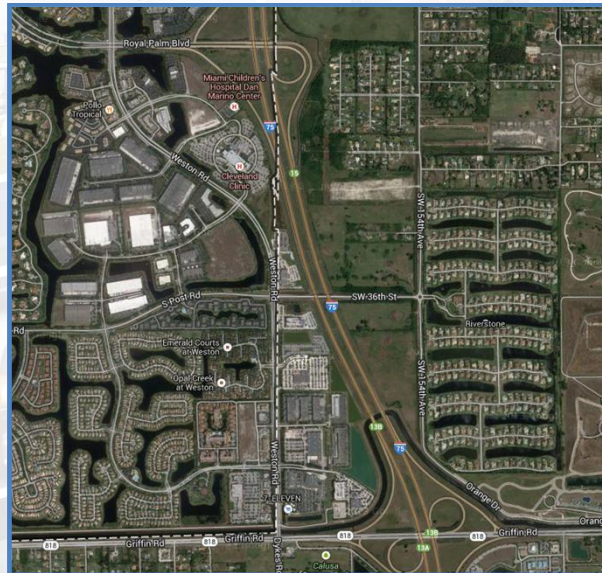
## Basic Freeway Segments

### Workshop #15: I-75 NB from Griffin Rd to Royal Palm Blvd (Hollywood, FL)

- Select "Operations" Analysis, use Planning Data
  - AADT – 149,500 veh/day
  - K – 9% (FDOT "standard K")
  - D – 54%
- PHF – 0.94
- 4-lane freeway
- Level terrain
- 6% trucks and buses
- Primarily commuter traffic
- 75.4 MPH base free-flow speed
  - Lane width - 12.0 ft
  - Right-side lateral clearance – 6.0 ft
  - Total ramp density – 6 ramps/6 mi = 1.0 ramp/mi

161

## Basic Freeway Segments



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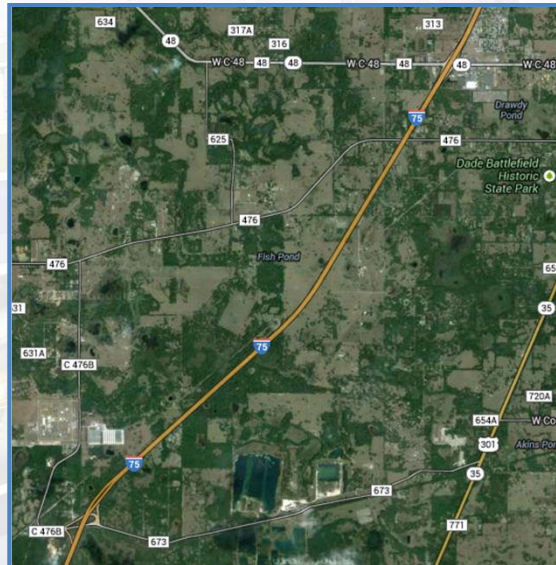
## Basic Freeway Segments

### Workshop #16A: I-75 NB from CR 673 to FL-48 (Bushnell, FL)

- Select "Operations" analysis, but don't check "Planning Data"
- Volume – 1,950 veh/hr
- PHF – 0.88
- Level terrain
- 2-lane freeway
- 20% trucks and buses
- 75.4 MPH base free-flow speed
  - Lane width – 11.0 ft
  - Right-side lateral clearance – 6.0 ft
  - Total ramp density – 4 ramps/6 mi = 0.66 ramps/mi

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## Basic Freeway Segments



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## Basic Freeway Segments

Workshop #16B: I-75 NB from CR 673 to FL-48  
(Bushnell, FL) – Continuation of problem 16 A

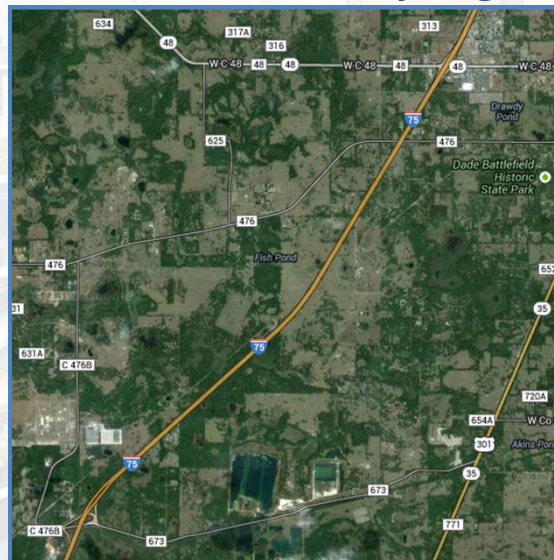
- Rather than Operations, select Design as the analysis type
  - Check box to enable Planning Data input fields
- Input same basic characteristics as Workshop #15A

How many lanes are required for LOS C?

- Assume:
  - AADT = 76,000 veh/day
  - K = 10%
  - D = 55%

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## Basic Freeway Segments



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## Day 3 – Uninterrupted Flow (Mostly)

- Interchanges
- Freeways
  - Basic segments
  - Weaving segments ◀
  - Merge and diverge segments
  - Freeway facilities
- Multi-lane highway segments
- Two-lane highway segments

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**HCS 2010**

## Weaving Segments

- Chapter 12 – *HCM 2010*
- Merge segments closely followed by diverge segments
- Three geometric characteristics affect a weaving segment:
  - Length of weaving segment based on short length
  - Width of weaving segment
  - Configuration
- Level-of-service criteria
  - Density (passenger cars/mile/lane)
- New methodology in *HCM 2010* based on NCHRP 3-75
  - LOS F threshold changes

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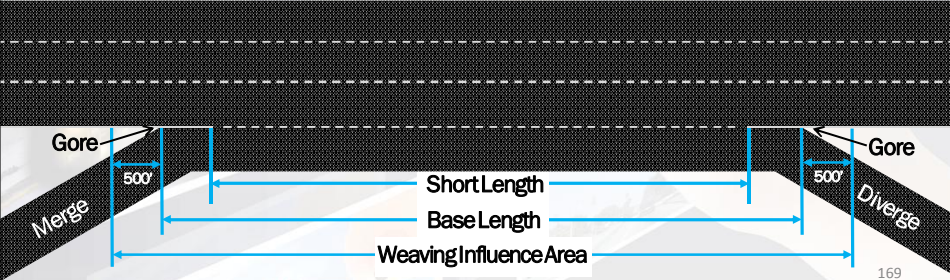


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## Weaving Segments

Terminology

- Length of Weaving Segment: Distance between the merge and diverge that form the weaving segment
  - Short Length: Distance between barrier markings
  - Base Length: Gore to gore length



The diagram illustrates a weaving segment on a multi-lane highway. It shows a merge area on the left and a diverge area on the right. Key measurement points are indicated: 'Gore' at the start and end of the segment, 'Merge' and 'Diverge' points, and 'Short Length' (distance between barrier markings) and 'Base Length' (gore to gore length). A 'Weaving Influence Area' is also shown. A 500-foot distance is marked from the merge point to the start of the short length.

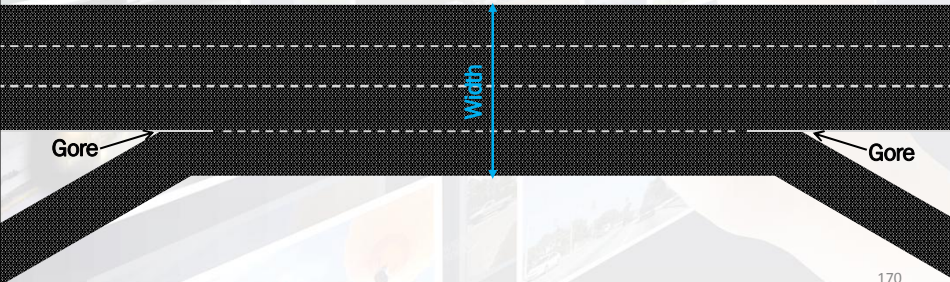
169

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## Weaving Segments

Terminology

- Width of Weaving Segment : Number of continuous lanes within a weaving segment
  - Number of lanes between the entry and exit gore



The diagram illustrates a weaving segment on a multi-lane highway. It shows a merge area on the left and a diverge area on the right. A vertical double-headed arrow labeled 'Width' indicates the number of continuous lanes within the weaving segment, measured between the entry and exit gore.

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## Weaving Segments

Terminology

- One-Sided Weaving Segment: Weaving maneuvers require no more than two lane changes
- One-sided ramp weave shown




The diagram illustrates a one-sided ramp weave on a highway. A main horizontal road with two lanes in each direction is shown. A ramp enters from the bottom left, merging into the left lane of the main road. A green dotted line with an arrow shows the path of a vehicle entering the ramp, weaving into the left lane, and then continuing straight. The number 171 is in the bottom right corner.

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## Weaving Segments

Terminology

- One-Sided Weaving Segment: Weaving maneuvers require no more than two lane changes
- One-sided major weave shown



The diagram illustrates a one-sided major weave on a highway. A main horizontal road with two lanes in each direction is shown. A ramp enters from the bottom left, merging into the left lane of the main road. A green dotted line with an arrow shows the path of a vehicle entering the ramp, weaving into the left lane, and then continuing straight. The number 172 is in the bottom right corner.

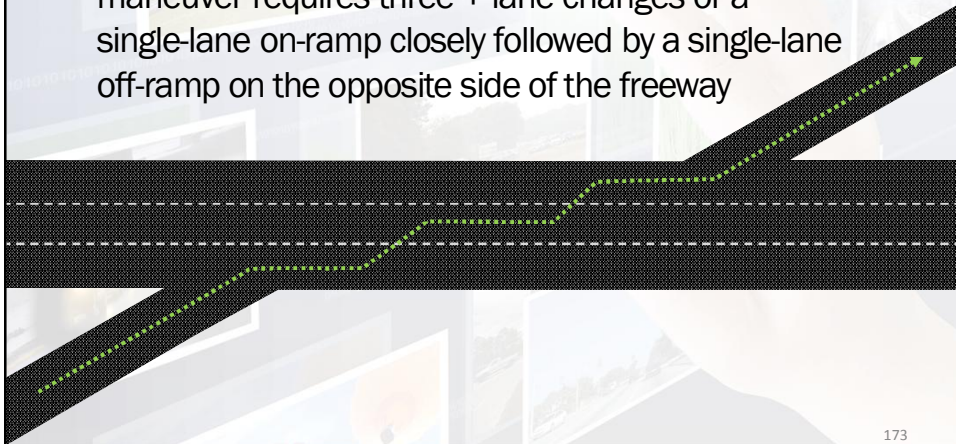


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## Weaving Segments

Terminology

- Two-Sided Weaving Segment: At least one weaving maneuver requires three + lane changes or a single-lane on-ramp closely followed by a single-lane off-ramp on the opposite side of the freeway



The diagram illustrates a two-sided weaving segment on a multi-lane freeway. A green dashed line with arrows shows a vehicle's path starting from an on-ramp on the left, weaving through multiple lanes to cross over the centerline, and then exiting via an off-ramp on the right. The freeway has multiple lanes in both directions, separated by a dashed centerline.


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## Weaving Segments

Maneuver Lanes

- Number of lanes from which a weaving maneuver may be completed with one lane change or no lane changes



The diagram shows three examples of weaving maneuvers, each labeled with a red circle containing a number. The first two examples are labeled '2', indicating two maneuver lanes. The third example is labeled '3', indicating three maneuver lanes. Each example shows a green dashed line with arrows representing a vehicle's path through a weaving segment, with the number of lanes from which the maneuver can be completed indicated by the label.

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## Weaving Segments

Minimum Lane Changes

- Minimum number of lane changes that must be made by a single weaving vehicle to successfully execute a:
  - Ramp to Freeway maneuver
  - Freeway to Ramp maneuver
  - Ramp to Ramp maneuver

Assume that every weaving vehicle enters in the lane closest to their desired exit leg and leaves the segment in the lane closest to their entry leg. This is only applicable for one-sided weaving segments.

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## Weaving Segments

Minimum Lane Changes

- Ramp to Freeway
- Freeway to Ramp
- Ramp to Ramp

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## Weaving Segments

- HCM 2010 Exhibit 12-10 (LOS for Automobiles)

LOS	Density (pc/mi/ln)	
	Freeway Weaving Segments	Weaving Segments on Multilane Highways or C-D Roadways
A	0-10	0-12
B	>10-20	>12-24
C	>20-28	>24-32
D	>28-35	>32-36
E	>35	>36
F	Demand exceeds capacity	

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## Weaving Segments

### Required Data

- Roadway configuration
  - Number of lanes on entry and exit legs
  - Number of lanes within weaving segment
  - Length of roadway segment
- Demand data
  - Volumes and PHF
    - Freeway to freeway, freeway to ramp, ramp to freeway, and ramp to ramp
  - Percentage of heavy vehicles

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# HCS 2010

## Weaving Segments

### Limitations

- Special lanes within weaving segment
  - HOV lanes, truck lanes, climbing lanes
- Ramp metering
- Influence from downstream congestion
- Posted speed limit and enforcement
- Impacts of Intelligent Transportation Systems (ITS)
- Weaving segments on arterials or urban streets
- Oversaturated conditions
- Multiple weaving segments

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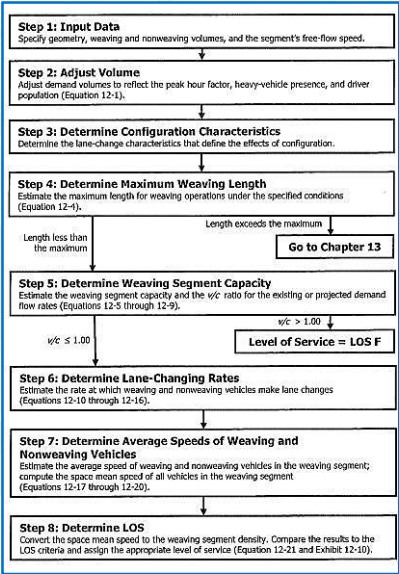


# HCS 2010

## Weaving Segments

### Methodology

- HCM 2010 Exhibit 12-6



```

graph TD
    Step1[Step 1: Input Data  
Specify geometry, weaving and nonweaving volumes, and the segment's free-flow speed.] --> Step2[Step 2: Adjust Volume  
Adjust demand volumes to reflect the peak hour factor, heavy-vehicle presence, and driver population (Equation 12-1).]
    Step2 --> Step3[Step 3: Determine Configuration Characteristics  
Determine the lane-change characteristics that define the effects of configuration.]
    Step3 --> Step4[Step 4: Determine Maximum Weaving Length  
Estimate the maximum length for weaving operations under the specified conditions (Equation 12-4).]
    Step4 -- "Length less than the maximum" --> Step5[Step 5: Determine Weaving Segment Capacity  
Estimate the weaving segment capacity and the v/c ratio for the existing or projected demand flow rates (Equations 12-5 through 12-9).]
    Step4 -- "Length exceeds the maximum" --> Exit[Go to Chapter 13]
    Step5 -- "v/c ≤ 1.00" --> Step6[Step 6: Determine Lane-Changing Rates  
Estimate the rate at which weaving and nonweaving vehicles make lane changes (Equations 12-10 through 12-16).]
    Step5 -- "v/c > 1.00" --> LOSF[Level of Service = LOS F]
    Step6 --> Step7[Step 7: Determine Average Speeds of Weaving and Nonweaving Vehicles  
Estimate the average speed of weaving and nonweaving vehicles in the weaving segment; compute the space mean speed of all vehicles in the weaving segment (Equations 12-17 through 12-20).]
    Step7 --> Step8[Step 8: Determine LOS  
Convert the space mean speed to the weaving segment density. Compare the results to the LOS criteria and assign the appropriate level of service (Equation 12-21 and Exhibit 12-10).]
            
```

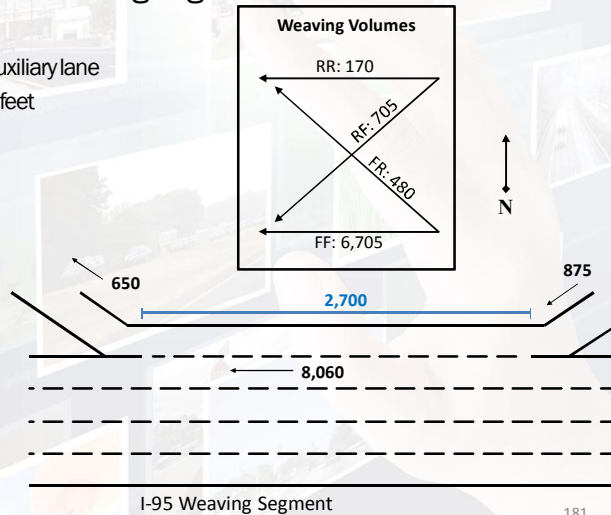
180



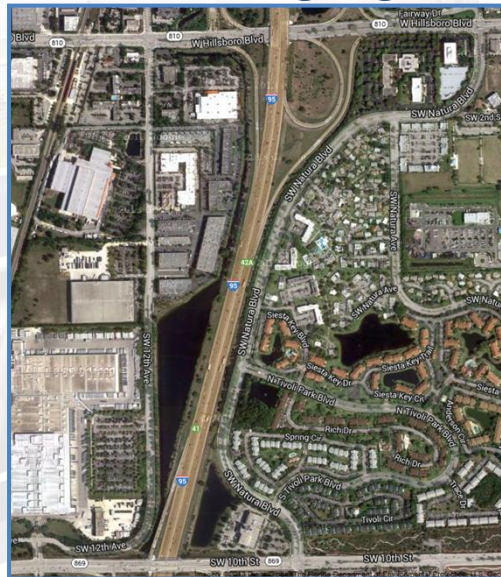
## Weaving Segments

**Example #9: I-95 NB weaving segment at 10th St**  
(Deerfield Beach, FL)

- 4-lane mainline, 1-lane auxiliary lane
- Segment length – 2,700 feet
- 70 mph FFS
- 55 mph ramp FFS
- 15 mph minimum speed
- PHF – 0.92
- 7% trucks and buses
- 1.3 interchanges/mile



## Weaving Segments

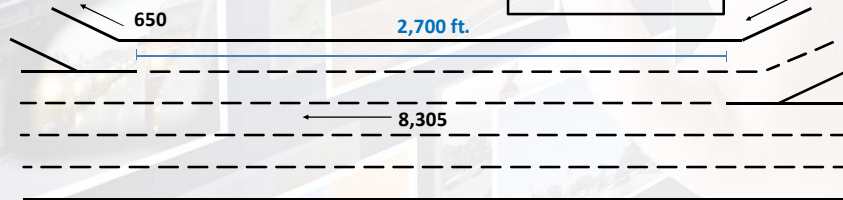
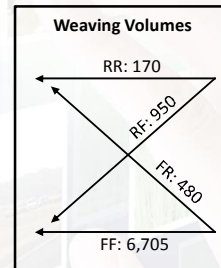




## Weaving Segments

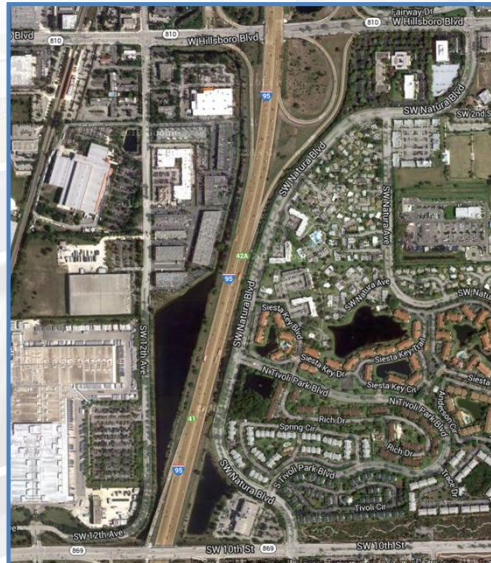
### Workshop #17: Sample Weaving Segment

- Add second on-ramp lane to Example #9
- Increased ramp to freeway (RF) volume



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## Weaving Segments



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## Weaving Segments

Workshop #18: Sample Weaving Segment

- 3-lane mainline, 1-lane ramps
- Segment length – 2,000 feet
- 70 mph free-flow speed
- 15 mph minimum speed
- PHF – 0.90
- 5% trucks and buses
- 1.0 interchange/mile

The diagram illustrates a weaving segment where a 3-lane mainline highway (with 1,150 vehicles per hour) is crossed by a 1-lane ramp (with 360 vehicles per hour). The ramp enters from the bottom left and exits at the top right. The mainline has a flow of 2,940 vehicles per hour. The ramp has a flow of 880 vehicles per hour. The segment length is 2,000 feet. The free-flow speed (FF) is 2,850, the ramp flow (RF) is 90, and the ramp rate (RR) is 270. A north arrow points upwards.

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## Day 3 – Uninterrupted Flow (Mostly)

- Interchanges
- Freeways**
  - Basic segments
  - Weaving segments
  - Merge and diverge segments** ◀
  - Freeway facilities
- Multi-lane highway segments
- Two-lane highway segments

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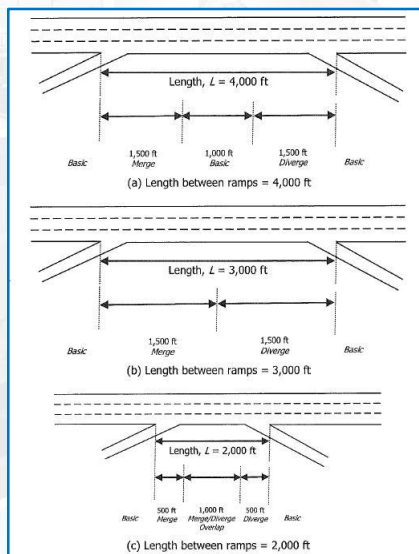
## Merge/Diverge Segments

- Chapter 13 – HCM 2010
- At ramp junctions on freeways without control
- Influence area
  - Merging (1,500 feet downstream of merge point)
  - Diverging (1,500 feet upstream of diverge point)
- Segments under base conditions
  - Good weather/visibility
  - No incidents/work zone activity/pavement deterioration
  - 12 foot lanes and adequate lateral clearances
- Level-of-service criteria
  - Density (passenger cars/mile/lane)

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## Merge/Diverge Segments

- HCM 2010  
Exhibit 10-12

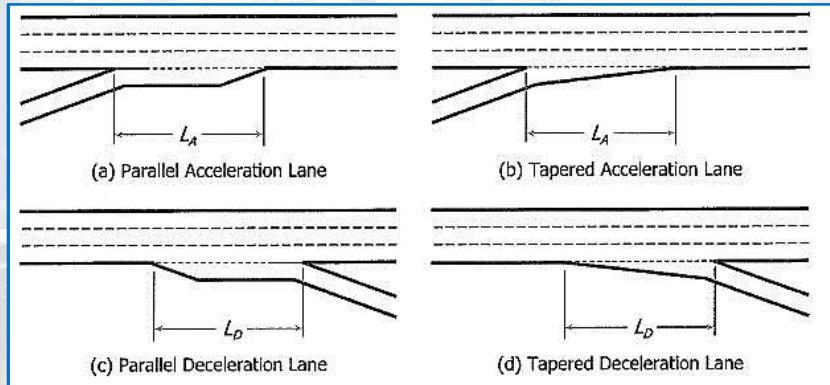


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## Merge/Diverge Segments

- HCM 2010 Exhibit 13-3



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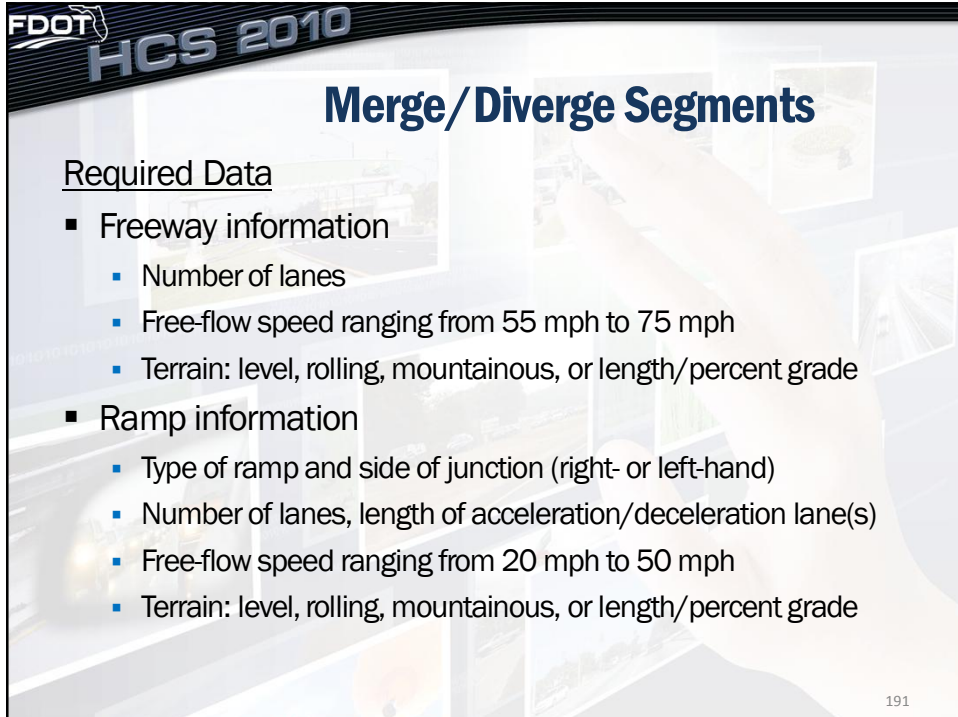
## Merge/Diverge Segments

- HCM 2010 Exhibit 13-2 (LOS for Automobiles)

LOS	Density (pc/mi/ln)	Comments
A	$\leq 10$	Unrestricted operations
B	$> 10-20$	Merging and diverging maneuvers noticeable to drivers
C	$> 20-28$	Influence area speeds begin to decline
D	$> 28-35$	Influence area turbulence becomes intrusive
E	$> 35$	Turbulence felt by virtually all drivers
F	Demand exceeds capacity	Ramp and freeway queues form

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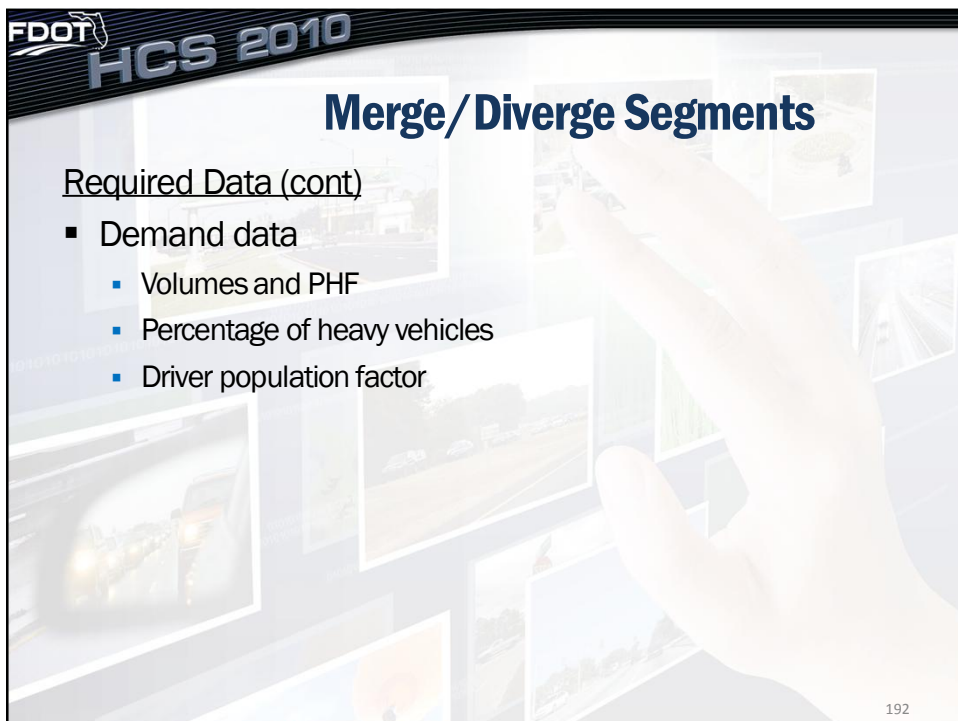
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**HCS 2010**

## Merge/Diverge Segments

Required Data

- Freeway information
  - Number of lanes
  - Free-flow speed ranging from 55 mph to 75 mph
  - Terrain: level, rolling, mountainous, or length/percent grade
- Ramp information
  - Type of ramp and side of junction (right- or left-hand)
  - Number of lanes, length of acceleration/deceleration lane(s)
  - Free-flow speed ranging from 20 mph to 50 mph
  - Terrain: level, rolling, mountainous, or length/percent grade

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## Merge/Diverge Segments

Required Data (cont)

- Demand data
  - Volumes and PHF
  - Percentage of heavy vehicles
  - Driver population factor

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## Merge/Diverge Segments

Limitations

- Special lanes including HOV lanes
- Ramp metering
- Posted speed limit and enforcement
- Impacts of Intelligent Transportation Systems (ITS)

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## Merge/Diverge Segments

Methodology

- HCM 2010 Exhibit 13-4

```

graph TD
    subgraph STEP 1
        A[Input Data  
Geometric Data  
FIS Inventory  
FIS Ramp  
Demand Flow] --> B[Demand Flow Adjustments  
Peak Hour Factor, PHF  
Heavy Vehicle Adjustment, KHV  
Driver Population Adjustment, KD]
        B --> C[Compute Adjusted Flow Rates  
Equation 13-1]
    end

    C --> D[On-Ramp (merge)]
    C --> E[Off-Ramp (diverge)]

    subgraph STEP 2
        D --> F[Compute demand flow rates in Lanes 1 and 2 immediately upstream of the merge influence area  
Equation 13-2 and Exhibit 13-6  
Check reasonableness  
Adjust as needed]
        E --> G[Compute demand flow rates in Lanes 1 and 2 immediately upstream of the diverge influence area  
Equation 13-8 and Exhibit 13-7  
Check reasonableness  
Adjust as needed]
    end

    subgraph STEP 3
        F --> H[Compute capacity of merge area and compare with demand flow  
Exhibit 13-8, Exhibit 13-9, and Exhibit 13-10  
Merge Area Capacity  
Ramp Roadway Capacity  
Maximum Flow Entering Merge Influence Area]
        G --> I[Compute capacity of diverge area and compare with demand flow  
Exhibit 13-8, Exhibit 13-9, and Exhibit 13-10  
Diverge Area Capacity  
Ramp Roadway Capacity  
Maximum Flow Entering Diverge Influence Area]
    end

    H --> J{Is demand greater than capacity?}
    I --> K{Is demand greater than capacity?}

    subgraph STEP 4
        J -- No --> L[Compute Density  
Equation 13-21]
        J -- Yes --> M[LOS = F  
Go to Chapter 10]
        K -- No --> N[Compute Density  
Equation 13-22]
        K -- Yes --> O[LOS = F  
Go to Chapter 10]
    end

    L --> P[Determine LOS  
Exhibit 13-2]
    N --> Q[Determine LOS  
Exhibit 13-2]

    subgraph STEP 5
        P --> R[Estimate Speeds  
Exhibit 13-11  
Exhibit 13-13]
        Q --> S[Estimate Speeds  
Exhibit 13-11  
Exhibit 13-13]
    end
  
```

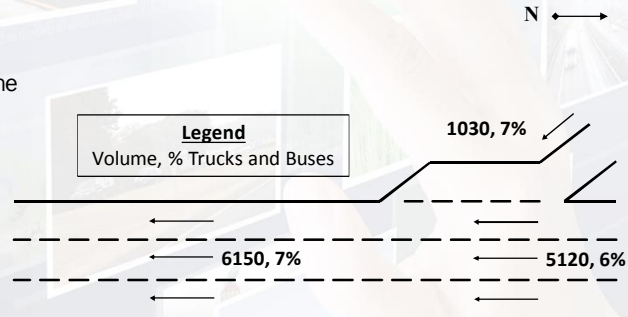
194



## Merge/Diverge Segments

### Example #10: I-75 SB/Griffin Road merge (Hollywood, FL)

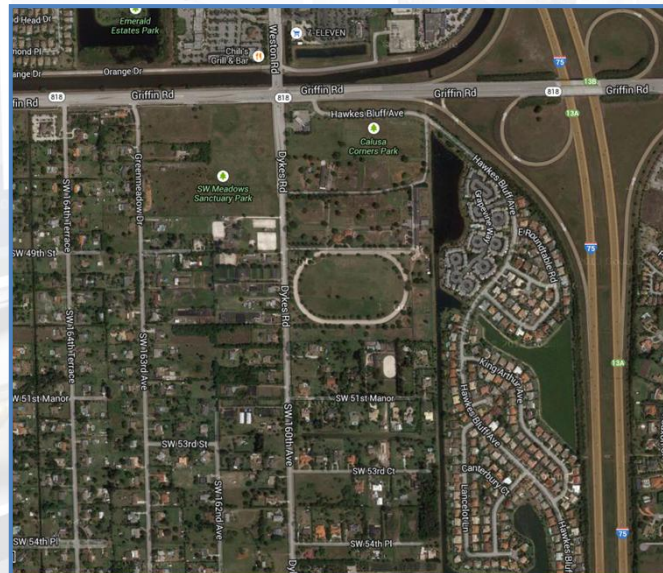
- 3-lane mainline, 1-lane ramp
- 70 mph mainline FFS
- 40 mph ramp FFS
- 1130 ft. acceleration lane
- PHF = 0.94
- 1% grade for 0.5 miles



I-75 / Griffin Road Merge

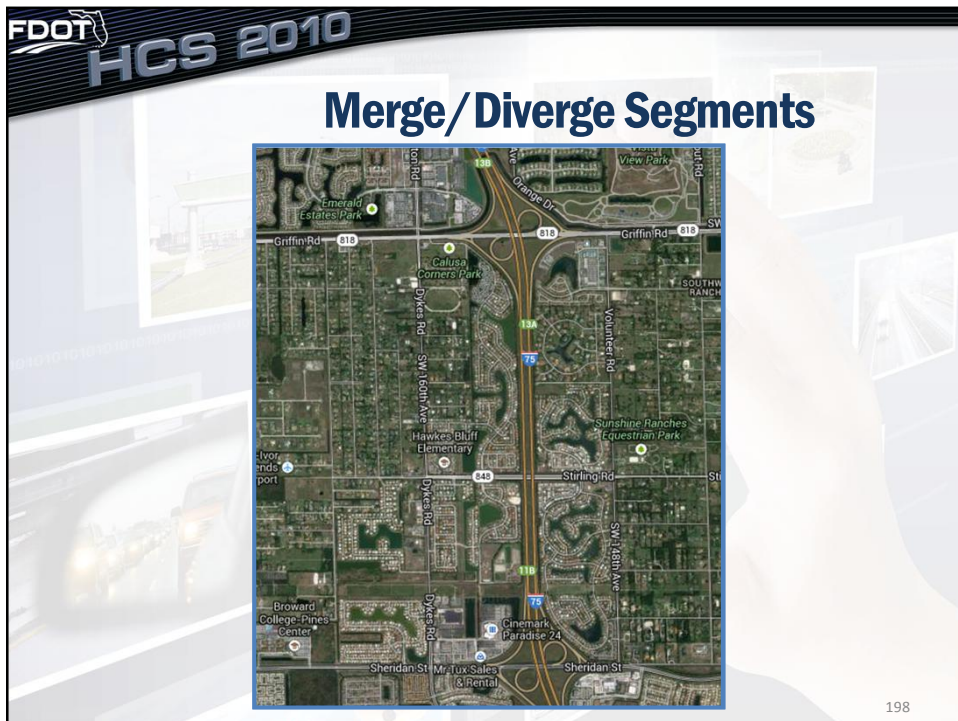
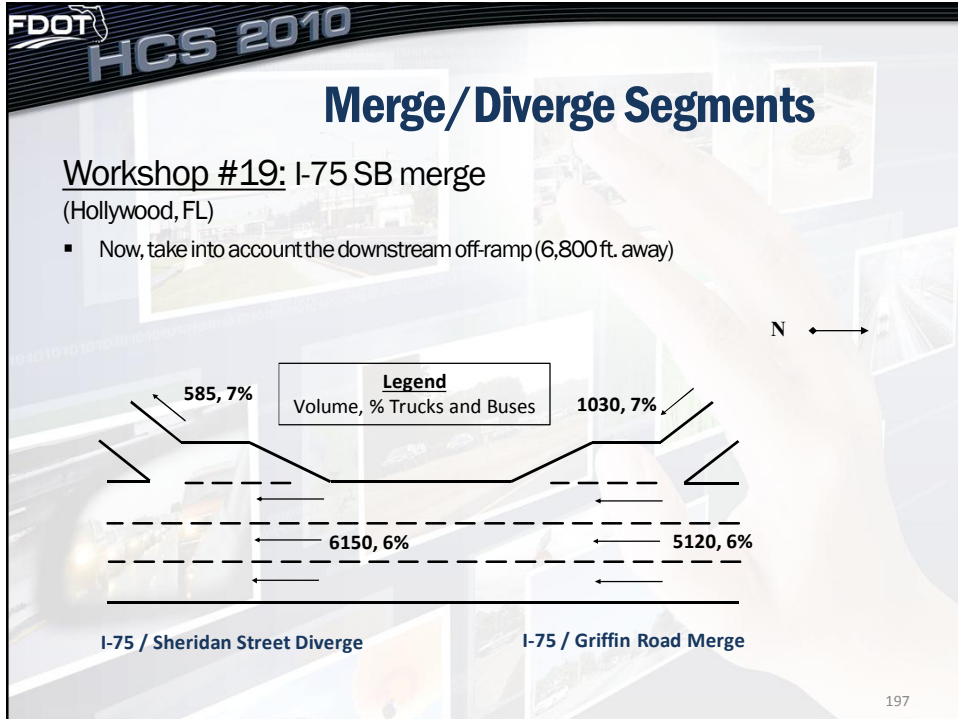
195

## Merge/Diverge Segments



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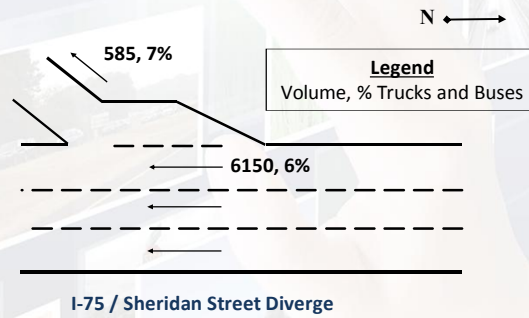




## Merge/Diverge Segments

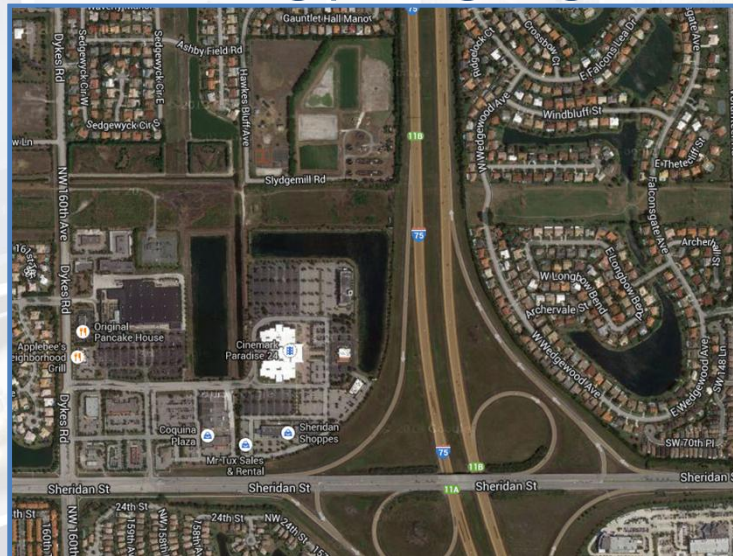
### Workshop #20: I-75 SB /Sheridan Street diverge (Hollywood, FL)

- 3-lane mainline, 1-lane ramp
- 70 mph mainline FFS
- 40 mph ramp FFS
- 480 ft. deceleration lane
- PHF – 0.94
- Level terrain



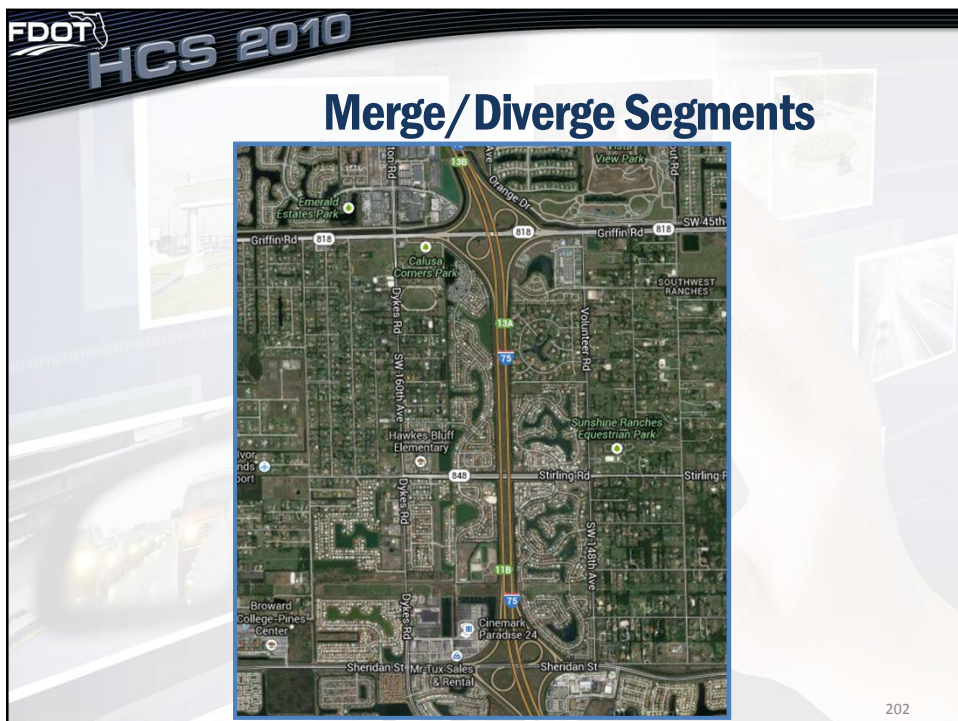
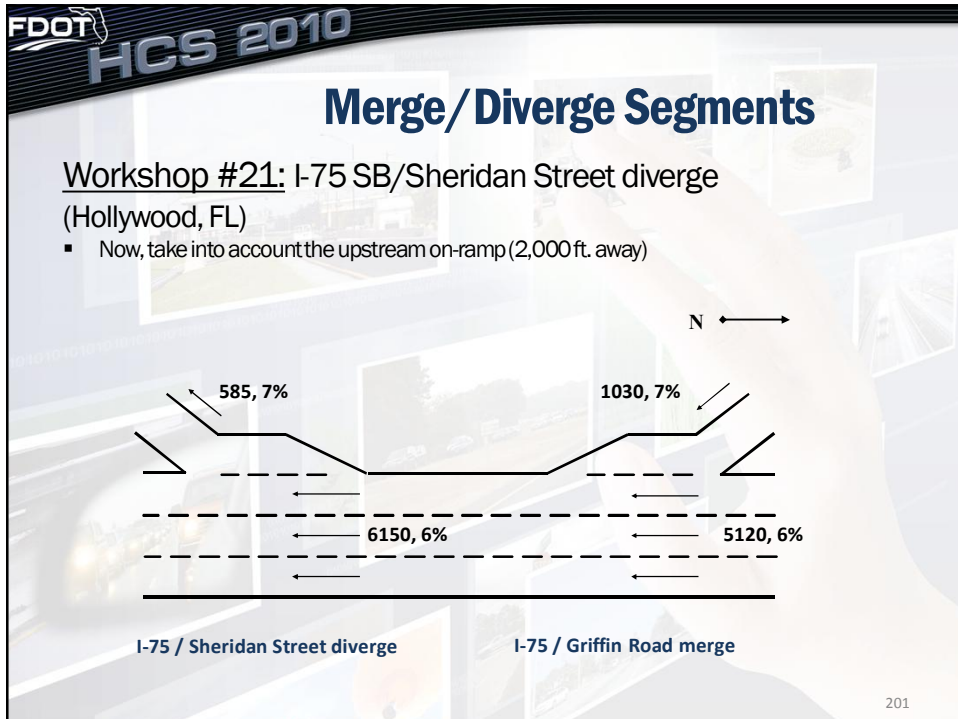
199

## Merge/Diverge Segments



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## Day 3 – Uninterrupted Flow (Mostly)

- Interchanges
- **Freeways**
  - Basic segments
  - Weaving segments
  - Merge and diverge segments
  - **Freeway facilities** ◀
- Multi-lane highway segments
- Two-lane highway segments

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## Freeway Facilities

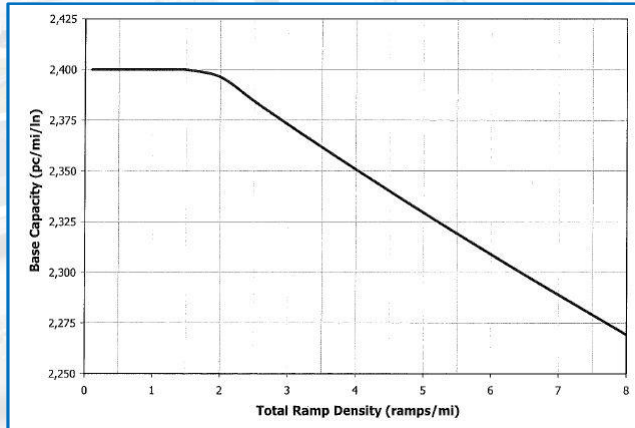
- Chapter 10 – *HCM 2010*
- Extended lengths of freeways
  - Including continuously connected basic freeway, weaving, merge, and diverge segments
- Multiple and continuous 15-min time periods
- Accounts for the spreading of impacts of breakdowns
- Freeway facility capacity is based on the capacity of the critical segment
  - Critical segment – the segment that will breakdown first
- Level-of-service criteria
  - Density (passenger cars/mile/lane)

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## Freeway Facilities

- HCM 2010 Exhibit 10-6



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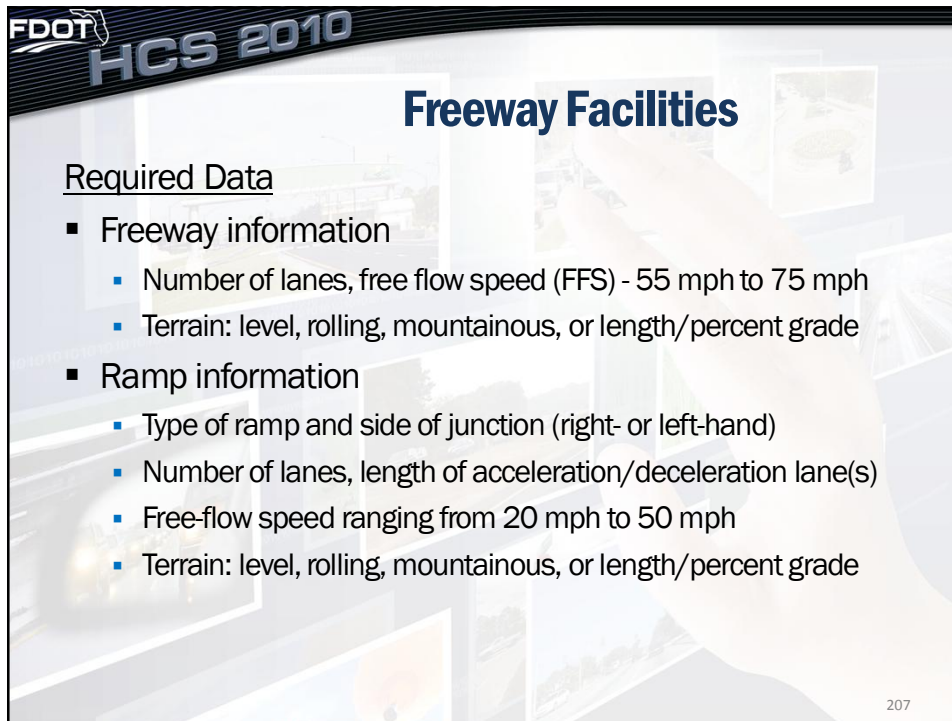
## Freeway Facilities

- HCM 2010 Exhibit 10-7 (LOS for Automobiles)

Level of Service	Density (pc/mi/ln)
A	≤11
B	>11–18
C	>18–26
D	>26–35
E	>35–45
F	>45 or any component $v_f/c$ ratio > 1.00

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## Freeway Facilities

Required Data

- Freeway information
  - Number of lanes, free flow speed (FFS) - 55 mph to 75 mph
  - Terrain: level, rolling, mountainous, or length/percent grade
- Ramp information
  - Type of ramp and side of junction (right- or left-hand)
  - Number of lanes, length of acceleration/deceleration lane(s)
  - Free-flow speed ranging from 20 mph to 50 mph
  - Terrain: level, rolling, mountainous, or length/percent grade

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## Freeway Facilities

Required Data

- Demand Data
  - Volumes and PHF
  - Percentage of heavy vehicles
  - Driver population factor

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## Freeway Facilities

### Limitations

- Multiple overlapping breakdowns or bottlenecks
- The effects of traffic management strategies
- System-wide oversaturation flow conditions
- Conditions where demand-to-capacity ratios  $> 1.00$
- HOV Lanes
  - HOV operating characteristics and their effect on rest of freeway
  - The interaction between HOV lanes and mixed-flow lanes
- The effects of off-ramp capacity issues
- The effects of toll plaza operations

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## Freeway Facilities

### Methodology

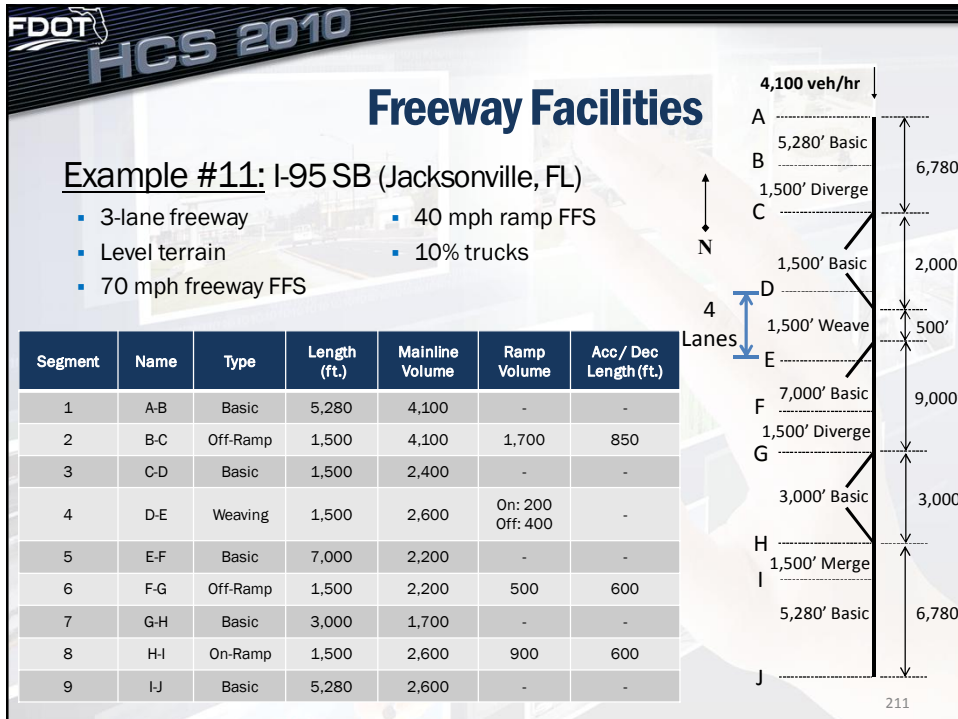
- HCM 2010 Exhibit 10-10

```

graph TD
    Step1[Step 1: Input data  
Demand  
Geometry  
Time-Space Domain] --> Step2[Step 2:  
Adjust demand according to spatial  
and time units established]
    Step2 --> Step3[Step 3:  
Compute segment capacities  
according to Chapter 11, 12, and 13  
methodologies]
    Step3 --> Step4[Step 4: Adjust segment capacities]
    Step4 --> Step5[Step 5:  
Compute demand-to-capacity ratios (v/c)  
All segments, on-ramps, and off-ramps]
    Step5 --> Undersaturated[Undersaturated]
    Step5 --> Oversaturated[Oversaturated]
    Undersaturated --> Step6A[Step 6A:  
Compute undersaturated segment  
service measures and other  
performance measures  
Assign segment levels of service]
    Oversaturated --> Step6B[Step 6B:  
Compute oversaturated segment  
service measures and other  
performance measures  
Assign segment levels of service]
    Step6A --> Step7[Step 7:  
Compute freeway facility service  
measures and other performance  
measures  
Assign appropriate level of service]
    Step6B --> Step7
  
```

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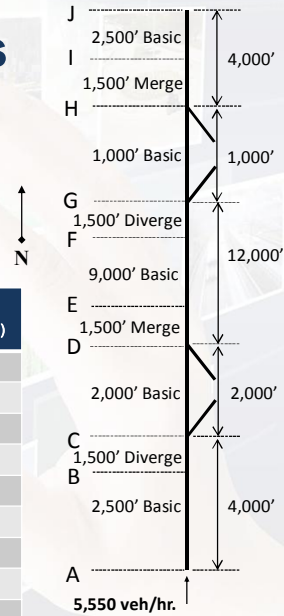


## Freeway Facilities

### Workshop #22: NB I-275 (Tampa, FL)

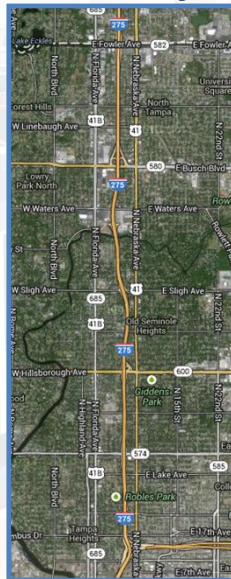
- 3-lane freeway
- Level terrain
- 75 mph freeway FFS
- 40 mph ramp FFS
- 8% trucks on mainline
- 3% trucks on ramps

Segment	Name	Type	Length (ft.)	Mainline Volume	Ramp Volume	Acc/Dec Length (ft.)
1	A-B	Basic	2,500	5,550	-	-
2	B-C	Off-Ramp	1,500	5,550	550	450
3	C-D	Basic	2,000	5,000	-	-
4	D-E	On-Ramp	1,500	6,000	1,000	700
5	E-F	Basic	9,000	6,000	-	-
6	F-G	Off-Ramp	1,500	6,000	250	450
7	G-H	Basic	1,000	5,750	-	-
8	H-I	On-Ramp	1,500	6,750	1,000	900
9	I-J	Basic	2,500	6,750	-	-



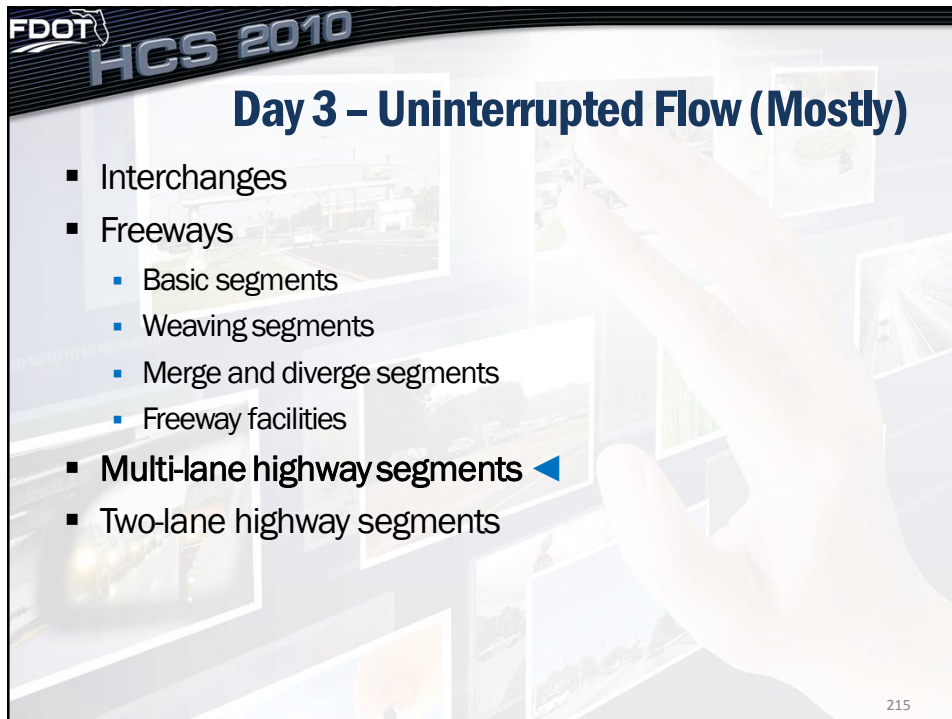
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## Freeway Facilities



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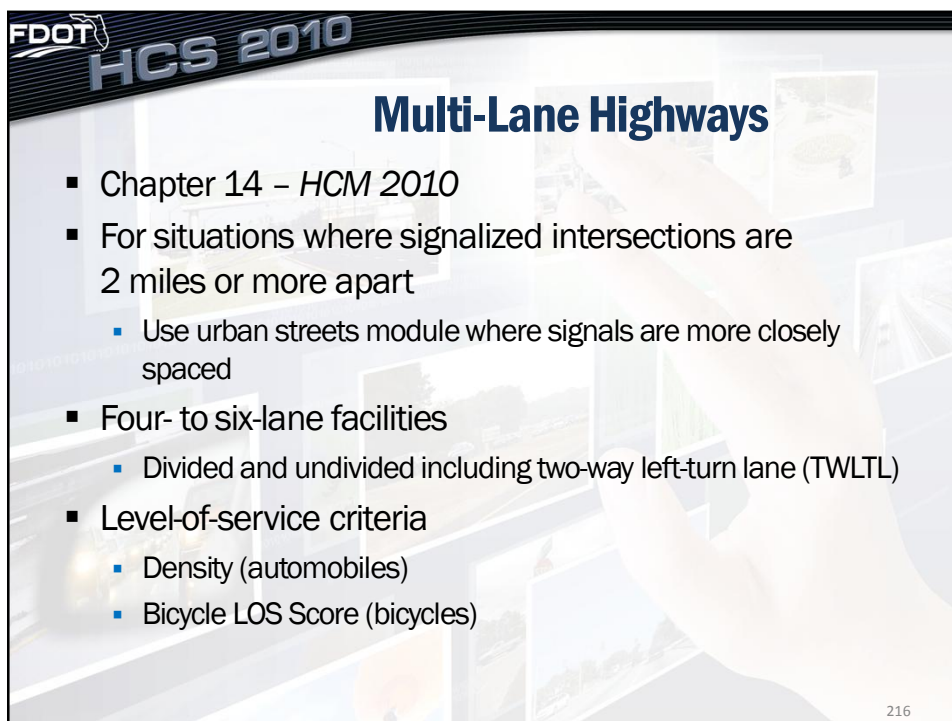


**FDOT HCS 2010**

## Day 3 – Uninterrupted Flow (Mostly)

- Interchanges
- Freeways
  - Basic segments
  - Weaving segments
  - Merge and diverge segments
  - Freeway facilities
- **Multi-lane highway segments** ◀
- Two-lane highway segments

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**FDOT HCS 2010**

## Multi-Lane Highways

- Chapter 14 – *HCM 2010*
- For situations where signalized intersections are 2 miles or more apart
  - Use urban streets module where signals are more closely spaced
- Four- to six-lane facilities
  - Divided and undivided including two-way left-turn lane (TWLTL)
- Level-of-service criteria
  - Density (automobiles)
  - Bicycle LOS Score (bicycles)

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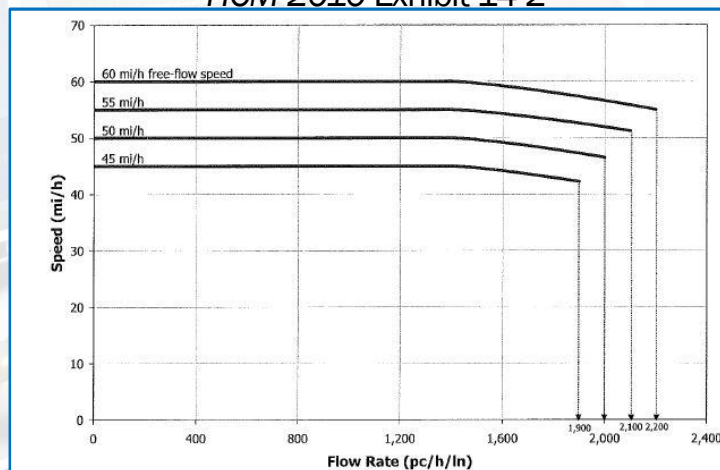
## Multi-Lane Highways



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## Multi-Lane Highways

### ■ HCM 2010 Exhibit 14-2



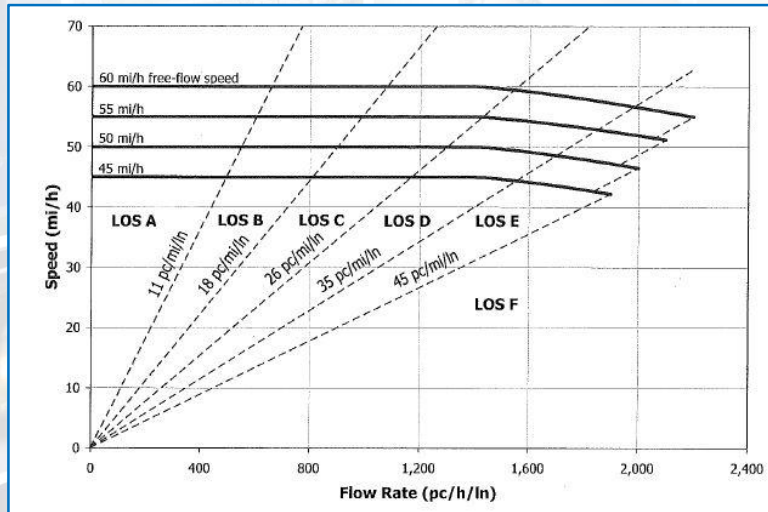
Note: Maximum densities for LOS E occur at a  $v/c$  ratio of 1.00. These are 40, 41, 43, and 45 pc/ml/ln for FFSS of 60, 55, 50, and 45 mi/h, respectively.

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## Multi-Lane Highways

### ■ HCM 2010 Exhibit 14-5



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## Multi-Lane Highways

### ■ HCM 2010 Exhibit 14-4 (LOS for Automobiles)

LOS	FFS (mi/h)	Density (pc/mi/ln)
A	All	>0-11
B	All	>11-18
C	All	>18-26
D	All	>26-35
E	60	>35-40
	55	>35-41
	50	>35-43
	45	>35-45
Demand Exceeds Capacity		
F	60	>40
	55	>41
	50	>43
	45	>45

### ■ HCM 2010 Exhibit 14-6 (LOS for Bicycles)

LOS	Bicycle LOS Score
A	≤1.5
B	>1.5-2.5
C	>2.5-3.5
D	>3.5-4.5
E	>4.5-5.5
F	>5.5

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## Multi-Lane Highways

### Required Data

- Number of lanes, lane widths, and lateral clearance
- Median type: divided, TWLTL, or undivided
- Free-flow speed (FFS) between 45 and 60 mph
- Access-point density (accesses/mile) between 0 and 40
- Terrain type
  - Level, rolling, mountainous, or length/percent grade
- Demand data
  - AADT, K factor and directional distribution (planning level)
  - Volumes and PHF
  - Percentage of heavy vehicles
  - Driver population factor

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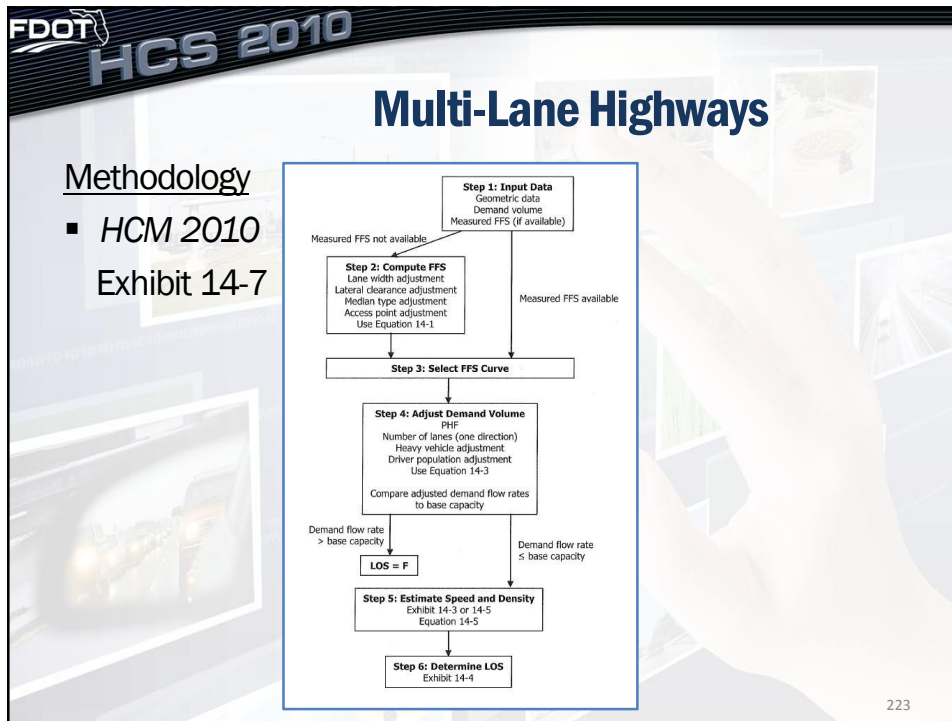
## Multi-Lane Highways

### Limitations

- Free-flow speed less than 45 mph and more than 60 mph
- The effect of lane drops/additions
- Downstream queuing effects
- Differences between median treatments
  - Barriers, raised curb and TWLTL
- The presence of on-street parking
- Significant transit and pedestrian activity
- The impacts of weather and incidents

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## Multi-Lane Highways

**Example #12:** US-19/27 from Avalon Rd to CR 14 (Lamont, FL)

- 4-lane divided highway
- 65 mph base FFS
- 12 ft. lane width
- 6 ft. lateral clearance on both edges
- Level terrain

Direction	Southbound	Northbound
Access Points per Mile	2	3
Hourly Volume	260	220
PHF	0.88	0.88
Trucks and Buses	12%	16%

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## Multi-Lane Highways

**Workshop #23: SR 289 (Pensacola, FL)**

- 4-lane undivided highway
- 50 MPH speed limit posted
  - 55 base free-flow speed
- 12 ft. lane width
- No lateral clearance on right edge
- Level terrain
- No on-street parking available
- Pavement rating: 5

Direction	Southbound	Northbound
Access Points per Mile	30	35
Hourly Volume	765	975
PHF	0.92	0.85
Trucks and Buses	5%	2%

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## Multi-Lane Highways

**Workshop #24: US-301 (Wildwood, FL)**

- 4-lane highway with TWLTL
- 40 MPH speed limit posted
  - 45 MPH base free-flow speed
- 12 ft. lane width
- 8 ft. lateral clearance on right edge
- Level terrain
- No on-street parking available
- Pavement rating: 4

Direction	Southbound	Northbound
Access Points per Mile	18	23
Hourly Volume	690	890
PHF	0.94	0.90
Trucks and Buses	11%	13%

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## Multi-Lane Highways

Workshop #25: SR 40 (Ormond Beach, FL)

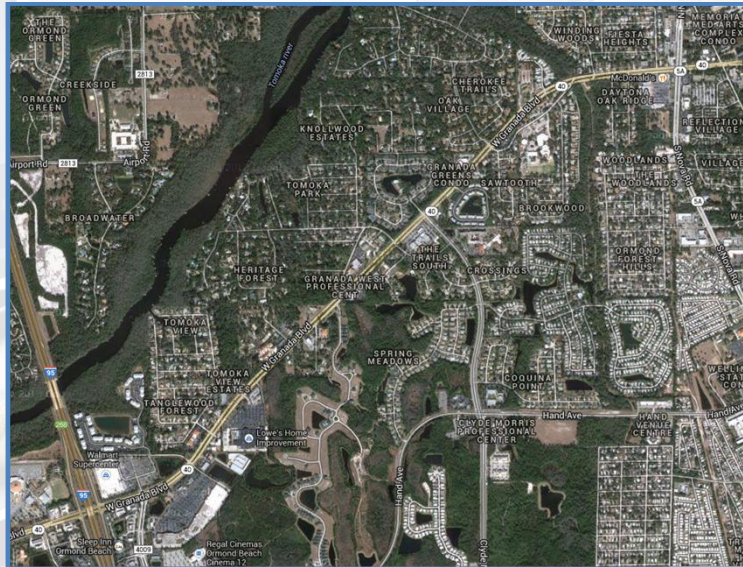
- 4-lane divided highway
- 45 MPH posted speed limit
  - 50 MPH base free-flow speed
- 11 ft. lane width
- 6 ft. lateral clearance on left edge
- No clearance on right edge
- Level terrain
- Driver population factor: 0.90
- No on-street parking available
- Pavement rating: 3

Direction	Eastbound	Westbound
Access Points per Mile	11	15
Hourly Volume	1,840	1,130
PHF	0.84	0.78
Trucks and Buses	9%	20%

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## Multi-Lane Highways



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## Multi-Lane Highways

### Workshop #26: US 27 (Haines City, FL)

- 6-Lane divided highway
- 50 mph posted speed limit
  - 55 mph base free-flow speed
- 12 ft. lane width
- 6 ft. lateral clearance to the left and right
- Level terrain
- No on-street parking available
- Pavement rating: 4

Direction	Eastbound	Westbound
Access Points per Mile	8	8
Hourly Volume	1,845	1,845
PHF	0.92	0.92
Trucks and Buses	9%	9%

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## Day 3 – Uninterrupted Flow (Mostly)

- Interchanges
- Freeways
  - Basic segments
  - Weaving segments
  - Merge and diverge segments
  - Freeway facilities
- Multi-lane highway segments
- Two-lane highway segments ◀

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## Two-Lane Highways

- Chapter 15 – HCM 2010
- Roadway segments generally 2-3 miles from the nearest signalized intersection with a single lane in each direction
- Serve a wide range of functions
- Classification System
  - Class I
  - Class II
  - Class III

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## Two-Lane Highways

**Class I Highway** – Primary connectors, long-distance trips, and high travel speeds



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## Two-Lane Highways

**Class II Highway** – Scenic routes, areas with rugged terrain and/or low expected speeds



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## Two-Lane Highways

**Class III Highway** – Moderately developed areas such as towns with more access points



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## Two-Lane Highways

- Passing occurs in the opposing travel lane
- LOS criteria for automobiles
  - Average Travel Speed (ATS)
  - Percent Time-Spent-Following (PTSF)
  - Percent of Free-Flow Speed (PFFS)
- LOS criteria for bicycles
  - LOS Score

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## Two-Lane Highways

- HCM 2010 Exhibit 15-3 (LOS for Automobiles)

LOS	Class I Highways		Class II Highways	Class III Highways
	ATS (mi/h)	PTSF (%)	PTSF (%)	PFFS (%)
A	>55	≤35	≤40	>91.7
B	>50-55	>35-50	>40-55	>83.3-91.7
C	>45-50	>50-65	>55-70	>75.0-83.3
D	>40-45	>65-80	>70-85	>66.7-75.0
E	≤40	>80	>85	≤66.7

- HCM 2010 Exhibit 15-4 (LOS for Bicycles)

LOS	BLOS Score
A	≤1.5
B	>1.5–2.5
C	>2.5–3.5
D	>3.5–4.5
E	>4.5–5.5
F	>5.5

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## Two-Lane Highways

Required Data

- Highway class – I, II, or III
- Lane widths, shoulder width and terrain
- Speed limit and base design speed
- Access point density (one side)
- Percent no-passing and/or passing lane length
- Demand data
  - Volumes and PHF
  - Percentage of heavy vehicles
  - Directional split

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**HCS 2010**

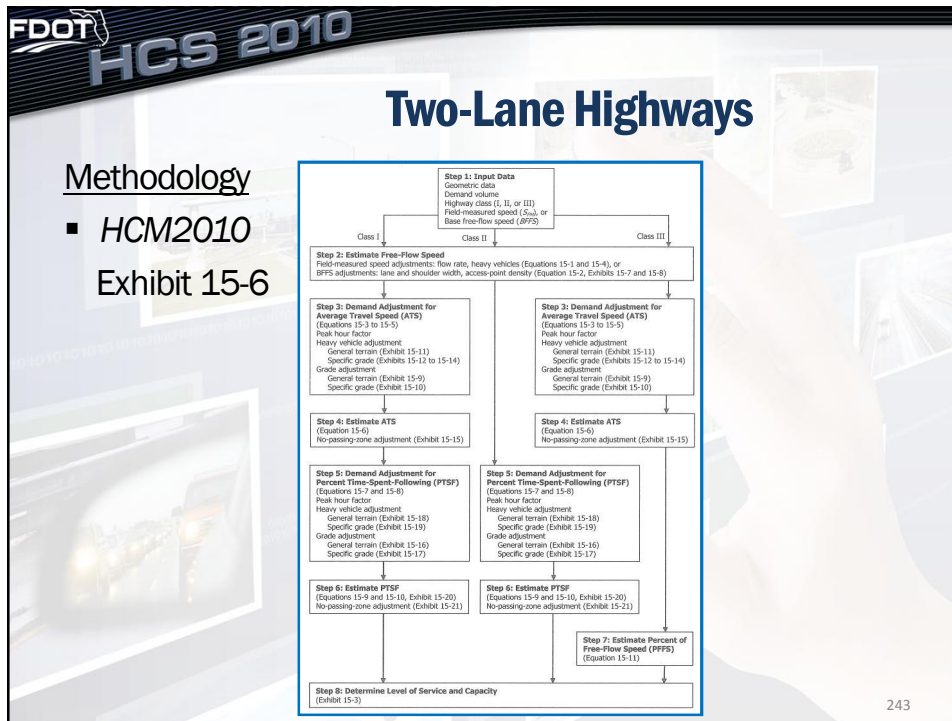
## Two-Lane Highways

Limitations

- Segments with signalized intersections
  - Streets module should be used to analyze isolated intersections
- Urban/suburban areas with multiple signalized intersections less than 2 miles apart
  - These situations should be analyzed using the Streets module
- Bicycle methodology adapted from urban & suburban data
  - Heavy vehicle percentages greater than 2%
  - Driver behavior factors may vary
  - Drivers slowing down for cyclists or drivers providing additional horizontal clearance while passing cyclists

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## Two-Lane Highways

**Example #13A: SR 490 (Lecanto, FL)**

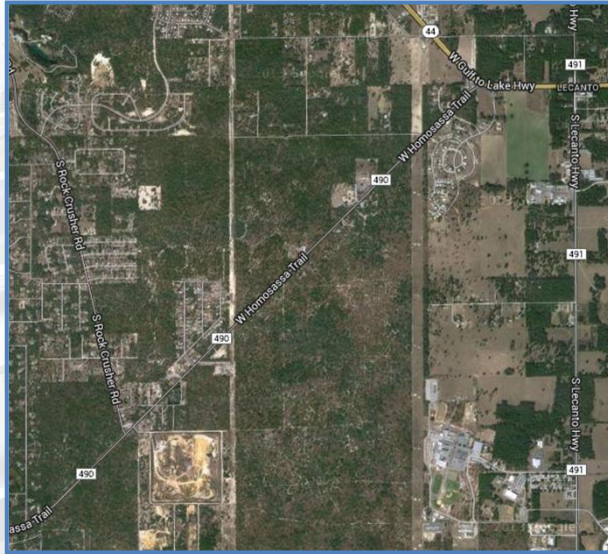
- Level terrain
- 2 ft. shoulder width
- 12 ft. lane width
- 6.0-mile corridor length
- Class I highway segment
- 90% no passing zones
- 10 access points per mile
- 55 mph base FFS (50 mph posted)
- Pavement rating: 3

Analysis Direction Volume	444 vph
Opposing Direction Volume	296 vph
PHF	0.85
Trucks and Buses	6%

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## Two-Lane Highways



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## Two-Lane Highways

### Example #13B: SR 490 (Lecanto, FL)

- Level terrain
- 2 ft. shoulder width
- 12 ft. lane width
- 6.0-mile corridor length
- Class I highway segment
- 90% no passing zones
- 10 access points per mile
- 55 mph base FFS (50 mph posted)
- Pavement rating: 3

Analysis Direction Volume	444 vph
Opposing Direction Volume	296 vph
PHF	0.85
Trucks and Buses	6%
<b>Passing Lane</b>	
Length Upstream of Passing Lane	1.5 mi
Length of Passing Lane Including Tapers	1.0 mi

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## Two-Lane Highways

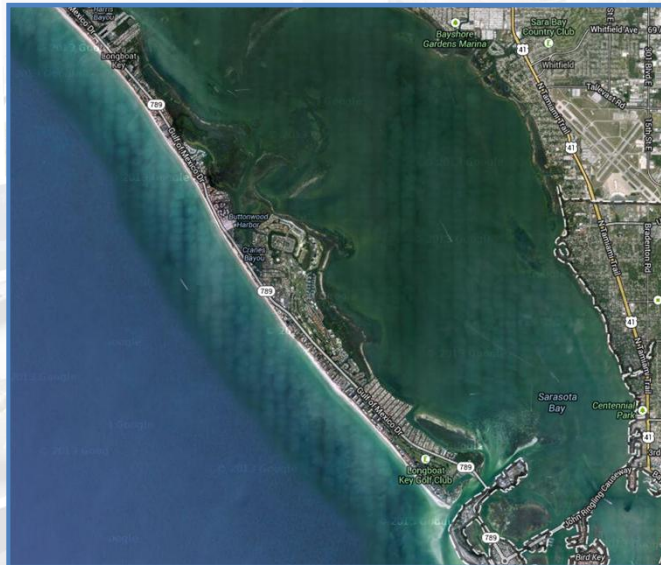
### Workshop #27: SR 789 (Sarasota, FL)

- Level terrain
- 4 ft. shoulder width
- 11 ft. lane width
- 17.7-mile corridor length
- Class III two-lane highway segment
- 70% no passing zones
- 25 access points per mile
- 55 mph base FFS (50 MPH posted)
- Pavement rating: 4

Analysis Direction Volume	684 vph
Opposing Direction Volume	456 vph
PHF	0.90
Trucks and Buses	4%

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## Two-Lane Highways



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## Two-Lane Highways

### Workshop #28A: SR 20 (Crawfordville, FL)

- Level terrain
- 6 ft. shoulder width
- 12 ft. lane width
- 14.5-mile corridor length
- Class II two-lane highway segment
- 62% no passing zones
- 13 access points per mile
- 60 MPH base FFS (55 MPH posted)
- Pavement rating: 4

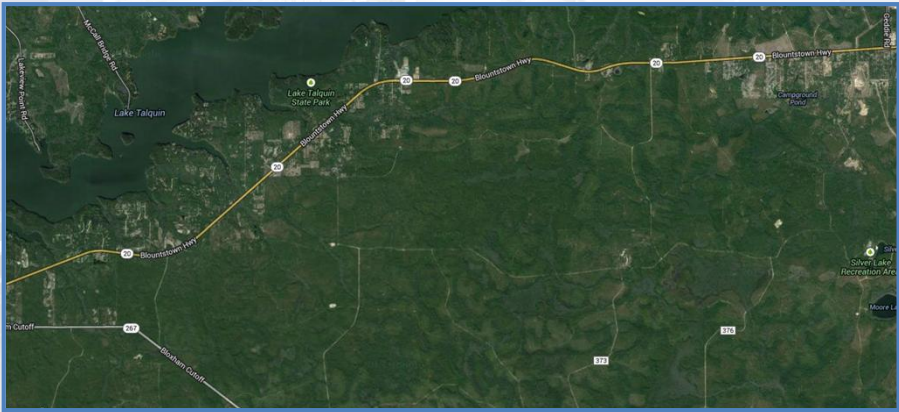
Analysis Direction Volume	353 vph
Opposing Direction Volume	182 vph
PHF	0.88
Trucks and Buses	7%

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## Two-Lane Highways



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## Two-Lane Highways

## Workshop #28B: SR 20 (Crawfordville, FL)

- Level terrain
- 6 ft. shoulder width
- 12 ft. lane width
- 14.5-mile corridor length
- Class II two-lane highway segment
- 62% no passing zones
- 13 access points per mile
- 60 MPH base FFS (55 MPH posted)
- Pavement rating: 4

Analysis Direction Volume	353 vph
Opposing Direction Volume	182 vph
PHF	0.88
Trucks and Buses	7%
<b>Passing Lane</b>	
Length Upstream of Passing Lane	10
Length of Passing Lane Including Tapers	2.5

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## Two-Lane Highways

## Workshop #29: SR A1A (St. Augustine, FL)

- Level terrain
- 2 ft. shoulder width
- 11 ft. lane width
- 15-mile corridor length
- Class III two-lane highway segment
- 80% no passing zones
- 25 access points per mile
- 55 MPH base FFS (50 MPH posted)
- Pavement rating: 3

Analysis Direction Volume	420 vph
Opposing Direction Volume	180 vph
PHF	0.90
Trucks and Buses	2%

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## Two-Lane Highways

Workshop #30: 8<sup>th</sup> Avenue (Gainesville, FL)

- Rolling terrain
- 2 ft. shoulder width
- 11 ft. lane width
- 2.5-mile corridor length
- Class II two-lane highway segment
- 60% no passing zones
- 10 access points per mile
- 50 MPH base FFS (45 MPH posted)
- 15% occupied on-highway parking
- Pavement rating: 4

Analysis Direction Volume	630 vph
Opposing Direction Volume	270 vph
PHF	0.85
Trucks and Buses	3%

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FDOT **HCS 2010**

## Wrap-Up

HCS 2010 versus HCS+

- New or Significantly Upgraded Modules
  - Roundabouts
  - Interchange Ramp Terminals
  - Urban Streets
- Increased focus on pedestrians and bicycles
- Viewable simulation using *TRAFVU*

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## Wrap-Up

### Contact Information

- Tim White
  - [tim.white@kimley-horn.com](mailto:tim.white@kimley-horn.com)
  - (804) 672-4705
- Brian Smalkoski
  - [brian.smalkoski@kimley-horn.com](mailto:brian.smalkoski@kimley-horn.com)
  - (651) 643-0472